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JOURNAL

OF THE INSTITUTION OF ELECTRICAL ENGINEERS

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MORE THAN A MUSEUM

IT IS NOT UNFITTING THAT 1957, THE CENTENARY year of London's Science Museum, has seen the opening of the Museum's new Electrical Power Collection, an event noted in our July issue. For Faraday's great discovery of 1831 was bearing fruit, about a century ago, in the first electrical machines of practical importance. Some of these, devised by the skilful hands of men such as Holmes, Siemens, and Wilde, have been discussed in the series of historical articles that have been rather fitfully appearing in the *Journal*. Some of them too are to be seen in the flesh among the varied exhibits of the new collection. From these early machines has stemmed nearly all the present vast range of heavy electrical apparatus, many up-to-date specimens of which can now be found at South Kensington. Indeed the electrical industry has been the principal source of the new exhibits, and it has given generously. It is gratifying to know also that The Institution has been able to be of some service in the establishment of the collection; an impartial authoritative body—non-commercial and yet closely in touch with its own industry—can usefully advise on industrial exhibits at what might be termed a 'scientific fair', so different in purpose and arrangement from the normal shop-window of industry—the trade fair.

Thus the hundred years of the Science Museum roughly span the development of electrical power engineering, although the year 1857 may not have witnessed any significant electrical event. The new electrical gallery is a fine tribute to the achievement of power engineers. We must hope that the resources of the Museum will soon allow it to treat radio and telecommunication engineering similarly: many individual light-current exhibits are on show on the first floor of the East Hall, but they invite more arresting arrangement in a gallery of their own. We know well, however, the difficulties of accommodation which have beset the Museum ever since the days when it shared a building with the forerunner of the Victoria and Albert Museum. The latter achieved a spacious new building in 1909. Even the first instalment of the corresponding building for the Science Museum recommended by the Bell Committee in 1912 was not finished till 1928; and the new building planned to be finished by 1961 will still leave about one-third of the Committee's recommendations to be implemented. Successive governments have for long relied on the Museum staff's ability to display a quart of material in a pint pot, by playing a game of perpetual motion with the exhibits. Successive governments have been largely non-scientific in their approach.

But we must not give the impression that this Electrical Power Collection is a centenary exhibition. The Museum authorities have been, no doubt, too busy in rehabilitating and enlarging the Museum to divert some of their slender resources to staging a special exhibition. Special exhibitions were much more common at the Science Museum in the inter-war years than they are now. (A small one at present illustrates the work of the International Geophysical Year.) The Museum authorities promise that they will be arranged more frequently 'when circumstances are again favourable'. One must hope that this will be soon, for such exhibitions provide a powerful method of interesting and informing the layman about particular facets of modern technology, their emphasis often being on present scientific activity rather than the history of science.

Nevertheless, the Science Museum has never lost sight of the fact that it has an educational role to play, in the sense of presenting up-to-date information about contemporary scientific and technological development. The original scientific collection at the South Kensington Museum of science and art was in fact known as the 'Educational Collection' and included class-room apparatus for use by teachers. This educational role has, since the eighteen-eighties, been balanced by the normal role of a museum—displaying objects of historical interest in the field which the museum covers. Furthermore, the authorities of the Science Museum regard it as one of their duties 'constantly to enlarge the common store of knowledge of the development of science from earliest times to the present day'.

Both the historical and the instructional activities of the Museum are in their own ways important for Britain to-day. The history of science, as is now recognized by many universities, provides one of the most useful bridges between education in humanities and education in science. But, of course, scientific history—and especially the evolution of scientific thought—cannot be learnt by looking at show cases and dioramas, any more than national history can be learnt by a visit to Madame Tussaud's or the Palace of Versailles. The historical exhibits in the Science Museum must be viewed mainly for interest—and highly interesting many of them are. Moreover the man with no scientific training will probably glean little from them. Not so the up-to-date exhibits—whether apparatus presented by industry, models constructed by the Museum staff, or merely wall diagrams such as those used to explain nuclear power generation to the layman. These find their chief target in the person who has no direct knowledge of, or training in, the subject-matter of the exhibit, but who is interested and keen to learn a little of present-day practice. This person may be a schoolboy or schoolgirl—and many of the Museum's visitors are, to the probable benefit of Britain's future army of scientists and technologists; or even someone seeking information outside his own specialty—and there must be few electrical power engineers (let alone light-current ones) who could not learn something from the Museum's new collection. No doubt this division into historical and instructional activities is oversimplifying the issues

(*continued on p. 480*)

Industrial Management for Professional Engineers

6. THE MANAGER AS A MEMBER OF A TEAM

by Sir George Nelson, Bart., Membe

The final article in this series is by a chartered electrical engineer who has proved to be outstanding in the field of industrial management. As Chairman of the English Electric group of companies, Sir George Nelson has for long emphasized the importance of Britain's industry to her international prestige as well as to her economy. Here he sets out a few general ideas which he believes to be important for good management, emphasizing the value of personal qualities, teamwork and human relations. Many will also be interested by his reference to the social responsibility of industrial firms and their managers to the communities around them. Some may think it a counsel of perfection to expect the hard-pressed industrial executive to become the local figure that was often so ably supplied in more leisurely times by the landowner, the retired officer, the successful small businessman, or the independent professional practitioner. But the quality of Britain's public and philanthropic activities cannot surmount the quality of the people guiding them. With an ever-increasing proportion of Britain's ablest men and women seeking employment in industry, the country will expect from her industrial managers rather more help in public affairs than on the average they give at present. How this can be arranged is, as Sir George writes, a 'major social problem'. Previous articles in the series appeared in the preceding five issues of the Journal (March–July

THE natural resources of Great Britain can support only about twenty million people, but on our island to-day there are living more than twice that number. The excess population is fed, clothed and housed by the money which we earn from our oversea activities—shipping, finance, insurance, etc., and, most important of all, exported products of our manufacturing industries. These products can be sold only if they are competitive in quality and price with those of other countries, and the responsibility for ensuring this is that of industrial managements; it is impossible to exaggerate the importance of the part such managements play in the interests of our country and its people. I therefore applaud The Institution's initiative in publishing in the *Journal* the present series of articles on management.

At the present time there is much written—good, bad and indifferent—on industrial management. Some, of course, is expert comment, but much comes from the inexperienced or from those who wish to fly a personal flag. In fact, it is difficult for practising managers, who are highly occupied men, to find time, first to sort the good sense from the bad and then to study the lessons it contains for the manufacturing units for which they are responsible.

Nevertheless, I do not wish to deprecate what is written by many, since all major advances in thought and action necessarily involve a great deal of discussion and heart-searching, and, although much of it may be little more than useless froth-blowing, fundamental thought is stimulated by such processes. At the time of the Renaissance or the Industrial Revolution, contemporaries may have felt that too much discussion revolved around particular problems, but it was through the clash of opinion that those new movements progressed. In the same way, the present spate of lectures, conferences, articles and discussions on management are of value if they stimulate fundamental thought on vital questions, and thereby encourage greater efficiency in this field. For, as I have written above, it is impossible to exaggerate the importance of industrial management and the responsibility borne by those who practise it. I think that members who have read the first five articles in the present series will agree that they are proving useful in stimulating such thought.

In several of the articles, references are made to the reports of the various Anglo-American productivity teams. I think that the most encouraging lesson learnt from these interchanges has been that the best British practices are equal to or better than the best in America or in any other country. I congratulate the management and work-people of the relevant firms, for, apart from any benefit they may themselves have received, they are undoubtedly public benefactors. It is, however, disturbing that the productivity teams were able to say that there is much room for improvement in many of our productive units by comparison with the average of corresponding American units. We are, therefore faced with the problem of raising as early as possible the average level of productivity to the level of the best. A major contribution to the solution of this problem would be to raise the standard of management in the industries concerned.

It is significant that the authors of the present series of

articles lay particular stress on personal relations. This aspect of management is, I believe, of prime importance: the essential factor is leadership. Leadership can neither be taught, nor be learnt from books. It arises from a natural flair in the individual applied to his knowledge of his own business, coupled with ability to choose the most effective team and to earn its loyalty. This is clearly indicated by the many examples of different results being obtained by two comparable organizations operating in the same field, solely because of the difference in quality of the leadership in the two organizations. Again, the conduct of a business has often been revolutionized by nothing more than a change in one man, the leader of the management team.

I referred to this in my Presidential Address to The Institution in 1955 and mentioned there the familiar but true dictum that men with the qualities of leadership are born and not made. I do indeed believe that the characteristics of leadership cannot be engendered in people who do not possess them already. These comments must not be taken to imply, however, that the training of managers can be left to chance. On the contrary, we must ensure that there are adequate facilities to educate, train and develop all men who have these qualities in some measure. There is a need in this country for men to exercise managerial responsibility at all levels in a great variety of fields, and we cannot rely on a handful who possess all the necessary gifts. We must enhance in others such gifts as they possess. This development of personal qualities must march hand-in-hand with the teaching of human relations and of the application of modern management techniques, including business organization, accountancy, work study, budgetary control, etc.

Details of management techniques can be taught theoretically in the class-room, but they must be paralleled by practical experience of the job and an opportunity to apply the techniques—in fact to exercise the personal responsibility of management. A balance between the class-room and factory is essential. Six months in charge of a small section in a works is better than six years' study of theory without practical experience. On the other hand, emphasis at too early an age on handling men on the shop floor, while teaching a young graduate valuable lessons in dealing with workers who are older, more skilled but less educated than himself, may mislead him about the problems of higher management. These will involve leading a team of executives who may well be younger but better educated than himself.

Training schemes for the development of executives in large companies take into account these different problems of theoretical knowledge, shop-floor training and the leadership of teams of executives. They cater for the different characteristics of the potential managers with the important object of maintaining a proper balance.

In some of the articles reference is made to management as a social practice, and a budding manager must realize that he is part of a social system in which he cannot figure in isolation; his major problems are fundamentally associated with the personal relationships between himself and those around him. In a large electrical organization, because of the complexity of its processes, an elaborate hierarchical structure has been developed, broadening from the Managing Director or General Manager down through the various functions of management. This involves a series of interlocking teams specializing in various managerial functions. The team which the Managing Director leads will include various experts and the managers of departments and factories, and these in turn have their own teams. Thus a factory or departmental manager, while being a member of the top managerial team, is in his own right a leader of his team. Similar considerations apply to all members of the hierarchy down to the charge-hand leading a team of operatives on the shop floor.

The management team requires the leadership of an energetic and enthusiastic chief executive ready to tackle and able to solve, in conjunction with his colleagues, diverse problems as they arise. But to maintain balance in the team he must find those whose character is complementary to his own. For example, the team should include someone with the gift for reflective and forward thinking, someone who can forecast the problems of tomorrow and plan the solutions, while his colleagues concentrate on the problems of to-day. The true leader must study his own personality not only to control it more effectively, but also to ensure that the colleagues in his team balance his own personality and are not mere reflections of it who become 'yes' men.

But one must remember that just because an engineer becomes expert in some particular branch of his profession, say as a machine designer or an instrument research engineer, he does not necessarily become a leader. The qualities he requires for successful leadership and management are quite different from those that have made him professionally able. They must be developed to the limit of his capability if he seeks to be a manager.

Because modern management is so largely a matter of teamwork, the choice of a young trainee is largely the question of deciding how he will fit into the team. For that reason close consideration must be given to his background, i.e. his relations with his family and his home, his school friends, his reaction to team games, the part he has played in the social life of his university or his local community, and the balance between his academic achievements and his athletic and social success. These matters are important not only in choosing potential managers but in planning their training and development. Modern selection methods give much more weight to this sort of background than was done in the past, and it is right and necessary that they should do so. Experience shows that the more successful a man is in adjusting himself to the various communities of the family, the school, the university, the Army and so forth, the more successful he will be in adjusting himself to the complex social system centred on an industrial undertaking.

I have referred so far to the internal problems of

industrial management, but industry itself has a considerable responsibility to the outside community. All the wealth that maintains our modern civilization, through whatever channels it is dispersed, comes basically from industrial enterprise. Industrial management in the United Kingdom has taken over many of the functions of the earlier ruling classes. The great industrial organizations, with works spread all over the country, have in some respects replaced those great mediaeval families who exercised power in the past; similarly the smaller companies play a part in modern society comparable to that of the squire of bygone days. In these days of high taxation, unfortunately there is little margin left to individuals to support the arts and charitable institutions. These were largely dependent in the past on richer individuals, and they now have largely to be supported by industry. Industry recognizes this partly by financial contributions and partly by its efforts in providing amenities. Thus, for example, in many British towns to-day the standard of factory architecture is higher than that of domestic architecture.

A real problem, however, arises over the ability of those employed in industry to give personal services to the community. More and more of the best brains of the country are being recruited to industry, and it is natural that their services should be sought in various local activities. It would be unfortunate indeed if society were not able to obtain the value and ability of such people, but the fact remains that if the manager is to do his job properly in industry he must concentrate on it to a degree which unfortunately leaves insufficient time for outside activities. This undoubtedly is a major social problem whose solution will require much thought.

Our country's survival and greatness depend on our ability to develop our national characteristics through a team spirit manifest in all our activities and at all levels, but especially in industry. This is the key to morale, productivity and efficiency, and thence to our standard of living and to our ultimate survival. For, as the Prime Minister has reminded us, our nation is great and must remain so, not only for our own benefit but for that of the world.

ELECTROLUMINESCENCE AND ITS APPLICATIONS

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Phosphorescence has puzzled man from early times. The ghostly, wavering light of fireflies, glow-worms and luminous fishes has passed into legend and has aroused in turn superstitious fear and—curiosity. With increasing rationalism came the conception of 'cold light', but not until the elucidation of atomic structure was any explanation forthcoming.

In this article the author, who is with the Research Laboratories of the General Electric Co. at Wembley, describes the stimulation of luminescence by alternating electric fields, and the applications and limitations of the phenomenon. 'Cold light' remains outside our grasp, but the search continues unabated.

J. N. BOWTELL, B.SC., A.INST.P.

LUMINOUS effects produced in phosphors by the direct application of electric fields have been studied for nearly forty years. Early workers noticed varying degrees of enhancement or quenching by electric fields of both fluorescence and phosphorescence in zinc sulphide and other phosphors. Such effects are usually described as *electrophotoluminescence* and are still the subject of academic study.

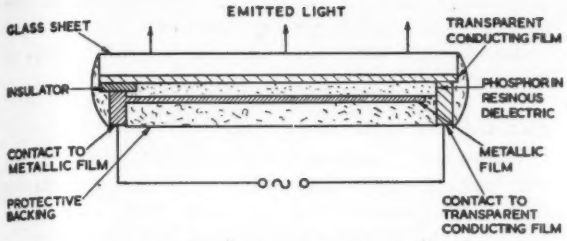
Electroluminescence is a particular manifestation of this phenomenon, and may be defined as the continuous emission of light from a phosphor dispersed in a suitable medium and excited solely by an alternating electric field. Destriau in 1936 first observed this effect and drew attention to its possibilities as a new form of light source.

In the last ten years, intensive efforts have been made by all the larger industrial lamp-research laboratories to develop an electroluminescent light source of acceptable luminosity, colour and luminous efficiency. This limited objective has not yet been achieved; instead there has been a tendency in the past two or three years to concentrate more on certain specialized applications of electroluminescence, such as its use in light amplifiers. Nevertheless, in the present brief survey it is proposed to treat this subject mainly from the light-source aspect, in view of the more extensive knowledge in this field.

Construction

Fig. 1 shows in diagrammatic form the construction of an electroluminescent light source. The thickness is greatly exaggerated for clarity. The phosphor, in the form of fine crystalline powder dispersed in a resinous dielectric, is sandwiched in a thin layer between two electrodes. One of these is of necessity transparent to permit the light from the phosphor to emerge. In a common form of construction, the main supporting member is a glass panel, one surface of which is treated with stannic oxide to form the transparent conducting electrode. Treatment of the glass surface with cadmium oxide, or the deposition of a thin evaporated layer of gold, also provides a satisfactory transparent conducting surface.

The dielectric layer containing the phosphor is applied to this surface, and the second electrode is usually a thin aluminium layer evaporated onto the dielectric. Two small metal pads fixed to the corners or edges of the



1 *Construction of electroluminescent panel*
The thickness is greatly exaggerated.

panel, and connected one to each electrode, serve as electrical contacts. The device is finished by applying over the rear surface a suitably robust covering, which protects the layers beneath from mechanical damage, insulates them electrically, and prevents the ingress of moisture and other contaminants. Panels of this type are shown in Fig. 2.

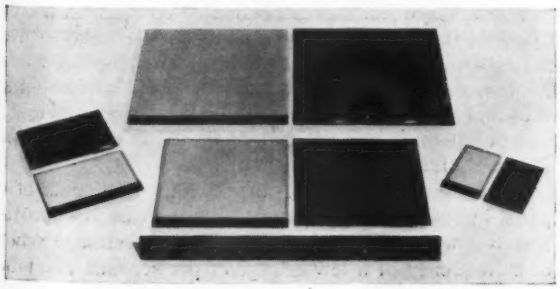
In another method of construction developed in the United States, the various layers are applied by special enamelling techniques to a thin sheet of steel, as shown in Fig. 3 (p. 456). By this means panels in any desired shape can be readily produced by blanking out the sheet steel member. Furthermore, these panels can be made to have some degree of flexibility for fitting to curved surfaces.

Electroluminescent Phosphors

The dielectric layer of electroluminescent panels designed for 240-volt 50 c/s operation is about 50 microns thick and is therefore subjected to a peak electric field in the region of 70 000 volts/cm. Under this rapidly reversing field the specially prepared phosphor embedded in the dielectric emits a broad pulse of light each half cycle shortly before the instant of maximum voltage, as shown in the waveforms of Fig. 4. The current in the panel is also shown, and, since the device is in essence a capacitor, is seen to lead the voltage.

On 50 c/s mains, 100 pulses of light are emitted each second, and these, of course, are merged by the eye to give an apparent continuous emission of light by the phosphor.

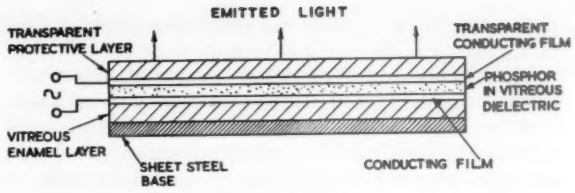
2 *Typical electroluminescent panels showing front and rear surfaces*
The rule shown in the foreground is 12 inches long



The well-known zinc-sulphide group of phosphors, suitably prepared, are the most outstanding in exhibiting field excitation in this way, and are accordingly used almost exclusively in electroluminescent devices. Zinc sulphides prepared for excitation by ultra-violet radiation show little or no excitation at field strengths several times higher than the 70 000 volts/cm just mentioned. In ultra-violet phosphors, the impurity, or activator, essential in rendering them luminescent, is incorporated in the crystal lattice in minute quantities of the order of 1 part in 50 000 of the host material. Electroluminescent phosphors are characterized, however, by high activator concentrations of about 1 part in 500. By variations in the amount and type of activator element, and in the method of preparation, a range of colours from blue to orange can be produced in much the same way as in ultra-violet-excited sulphide phosphors. The table lists the more important electroluminescent materials and gives brief details of their properties. Zinc sulphoselenide phosphors exhibit electroluminescence, and, although not used to any extent in electroluminescent devices, they are comparable in performance with the zinc sulphides and can be prepared in a similar range of colours. A red zinc sulphide is included in the table, but in general the brightness of electroluminescent phosphors

Characteristics of the More Important Electroluminescent Phosphors

Phosphor	Activator	Colour	Approximate performance in panel designed for 240-volt 50c/s supply	Approximate performance in panel designed for 4 600-volt 500 c/s supply
			ft-lamberts	ft-lamberts
Zinc sulphide	Copper and chlorine	Green	2	50
Zinc sulphide	Copper and chlorine	Blue	1·3	38
Zinc sulphide	Copper and manganese	Yellow	1	35
		Red (from yellow phosphor using red filter)	0·03	1
		Off-white (from mixture of blue and yellow phosphors)	1·2	36
			Assessment of relative luminance	
Zinc sulphoselenide	Copper	Green to orange	Moderate to strong (comparable with zinc sulphides)	
Zinc sulphoselenide	Copper	Orange-red		
Zinc sulphide	Copper	Red	Moderate	
Zinc silicate	Manganese	Green	Weak	



3 *Construction of electroluminescent panel using an enamelling technique on a sheet steel base*
The thickness is greatly exaggerated.

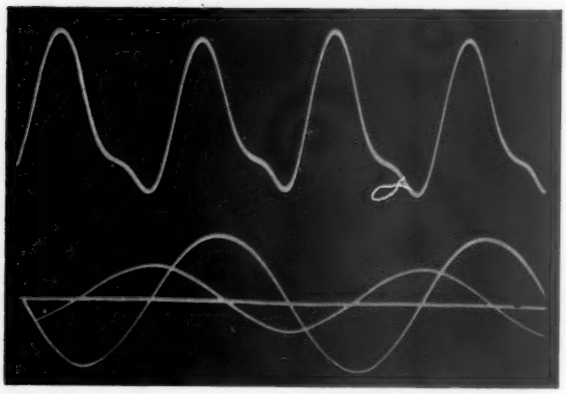
of truly red colour is somewhat disappointing. Reddish colours may be produced by using a suitable red filter with an orange or yellow phosphor, but these are, of course, lacking in deep red radiation. A subjective white can be obtained by mixing blue and yellow phosphors, but the development of a white with good colour-rendering characteristics depends on finding a satisfactory red phosphor.

Physical Basis

While the underlying principles of electroluminescence are broadly understood, there is as yet little understanding in detail of the processes involved.

In a much simplified description of the process it may be assumed that there are always a number of electrons free to move within the tiny crystallites of the phosphor. These are accelerated by the action of the applied field and gain sufficient energy to excite luminescence within the crystallites by well-known collision processes. The mechanism is not dissimilar to excitation by cathode rays, except that there electrons are made to bombard the phosphor particles from without. The individual crystallites of electroluminescent phosphors are known to differ from other classes of phosphor in having a surface composition and structure somewhat different from those of the interior, owing probably to the relatively large amounts of activator which are needed in their preparation, and which become concentrated in the surface. This inhomogeneity produces intense local excitation by concentrating the field in small regions of the crystallites.

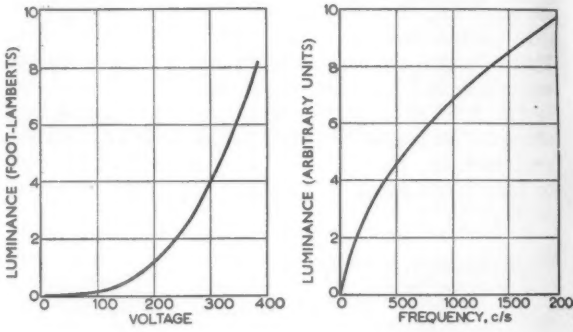
4 *Waveforms of electroluminescent panel*
a Light output. b Voltage. c Current.



Electrical and Luminous Characteristics

Theoretical calculations of the luminous efficiency of electroluminescent processes have yielded figures in the range 10–20 lumens/watt for green light, with corresponding figures of 4–8 lumens/watt for white light. As will be seen below, even these low values have not been approached in practical devices, and it would appear at the moment that in the field of electroluminescence the attainment of luminous efficiencies competitive with conventional light sources must await some fundamentally new discovery.

The luminance, or photometric brightness, of an electroluminescent panel increases rapidly with voltage (i.e. with the field applied to the phosphor), as shown in Fig. 5*a*. The

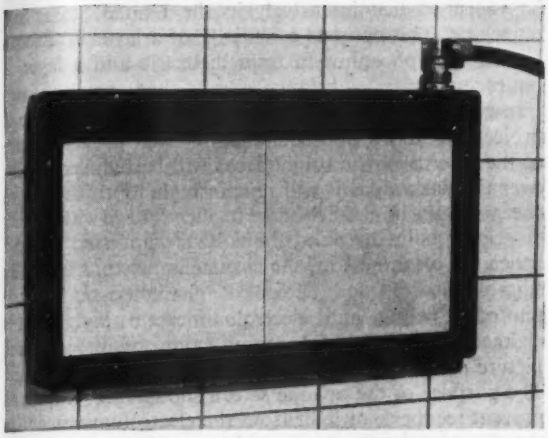


5 *Typical characteristics of an electroluminescent source*
a Voltage/luminance relationship.
b Variation of luminance with frequency.

relationship which best fits the voltage-luminance curves for the more important electroluminescent phosphors, and has some merit on theoretical grounds, is of the form $L = A \exp(-b/\sqrt{V})$, where L and V are luminance and voltage respectively and A and b are constants. For practical purposes covering a limited voltage range, the expression $L = kV^n$ is adequate; k and n are constants depending mainly on the nature of the phosphor. The value of n usually lies between 3 and 4.

The value of luminance obtainable from green panels operated from normal supply mains and designed to give a long life with adequate light maintenance is some 2 ft-lamberts. Luminance values are given in the fourth column of the table for panels in a range of colours using zinc-sulphide phosphors and designed to operate from 240-volt 50 c/s supplies.

Fig. 5*b* shows the manner in which the luminance of a panel increases with frequency. The increase is approximately linear at first, but a saturation effect supervenes at a frequency of a few kilocycles per second. The fifth



6 *Electroluminescent dark-room clock* (right) *and safe-light* (above)

column of the table gives typical luminance values for panels operated at 600 volts and 500 c/s.

Electrically, an electroluminescent panel possesses the characteristics of a capacitor with high dielectric loss. This loss may be considered to consist of two parts, the larger representing a hysteresis loss in which the energy is dissipated in the dielectric as heat, and the smaller in which the energy is converted to useful light by the phosphor. As would be expected, these losses increase markedly with voltage and frequency. Furthermore resistive losses occur in the electrodes, becoming substantial at high frequencies owing to the greatly increased current flowing in the device.

As mentioned above, the luminous efficiency of electroluminescent devices is disappointingly low, and strenuous efforts to improve it have yielded a value of about 5 lumens/watt for green panels for practical conditions of operation. By improved panel construction the losses already discussed might be reduced, and the quality of the phosphor improved, to give an efficiency of the order of 10 lumens/watt for green light, or some 3-4 lumens/watt for white light. By stressing panels to the limit in voltage and frequency, it is possible to achieve a dissipation of about 100 watts/ft^2 for short periods. At the enhanced efficiencies just mentioned this would correspond to a light emission of some 350 lumens/ft^2, or rather less than the output of a 40-watt tungsten-filament lamp. Even this modest performance has not so far been achieved in practical panels, in view of the severe impairment of life and lumen maintenance at high-wattage loadings. At the present time, the maximum loading consistent with reliable performance is about 10 watts/ft^2.

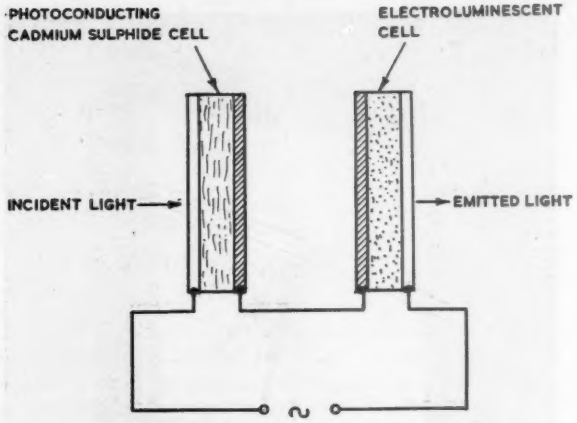
Lighting Applications

It will be clear from what has already been stated that the commercial use of electroluminescence for general-purpose lighting is an unlikely event in the near future. Its possibilities, however, have been explored for a number of specialized lighting applications, of which one or two have been tried on a fairly extensive scale.

The virtue of electroluminescent sources resides mainly in their extreme thinness, and they are well suited in locations where a large low-luminosity source of specific colour is required, but whose thickness is restricted. Applications of this type include the lighting of instruction notices in aircraft, instrument lighting, clock faces, radio panels, surrounds of television sets, theatre and cinema gangways, and obstructions such as the risers of isolated steps. On normal supply mains, the use of electroluminescent devices for this class of lighting would be restricted to relatively dark locations owing to the low luminance levels obtainable. Where higher-frequency supplies are available, such as in aircraft or radio equipment, this restriction would not, of course, apply.

However, since reasonably effective techniques for solving most of these lighting problems are already well established, the use of electroluminescent sources in their solution for these applications is unlikely to become widespread unless accompanied by a worth-while saving in cost.

A purpose for which electroluminescence is uniquely suited is the lighting of establishments engaged in the making and processing of photographic materials. Here, lighting must be restricted to the low illumination of essential equipment from sources safe to the particular emulsion in use. The illumination of all clocks, direction signs and the like must be equally safe. The conventional safe-light, consisting of one or more vacuum filament lamps in conjunction with a suitable filter, is widely used in a variety of forms for these different purposes. It suffers from the disadvantage that the sealing of the lamp housing against the leakage of white light is incompatible with the provision of adequate cooling ducts, and any overheating of the housing leads to



7 *Simple two-part electroluminescent light amplifier*

deterioration or cracking of the filter. Green electroluminescent panels with suitable spectral emission characteristics have been successfully adapted to meet most of the lighting needs in making and processing panchromatic film. Fig. 6 shows a typical electroluminescent dark-room safe-light and a clock with an electroluminescent dial used in a factory making photographic materials. The dark-room safe-light consumes less than one watt and the average life of the panels is about 4000 hours. A conventional safe-light of about the same size, colour and luminosity would consume 15–30 watts, and lamp replacement would recur at about every thousand hours.

Although this review has dealt mainly with electroluminescent sources in planar form, the various layers which go to make these devices can be applied to the interior of a conventional lamp bulb. Such lamps can be finished in the normal way with a bayonet cap for plugging into a 240-volt 50c/s supply, and offer a low-power source in a variety of colours for nursery lights or indicator lamps.

Light Amplifiers and Other Special Applications

The use of a flat large-area source for television displays is an attractive one, and a number of possible ways of employing electroluminescence for this purpose are being extensively studied. The problem is how to present the picture information on the screen with sufficient brightness and contrast.

Fig. 7 shows a light amplifying device in its simplest form. It consists of a photoconducting cell connected in series with an electroluminescent panel and an alternating voltage source. When light is allowed to fall on the photoconducting cell, its impedance decreases, current flows in the circuit, and the electroluminescent cell lights up. By suitable choice of circuit parameters, the emitted light flux can be made greater than the incident flux. This principle can be applied to image luminance amplification in a device, shown diagrammatically in Fig. 8*a*, which has been studied intensively in the United States and elsewhere. This consists essentially of a layer of electroluminescent phosphor in resin dielectric and a layer of photoconducting substance sandwiched between two transparent conducting glass sheets. When a picture is projected onto the photoconducting layer, the impedance of the layer over the bright areas will be reduced, whilst over the dark areas it will remain high. With the device energized, the luminance of the incident image will in effect determine point by point the voltage impressed on, and hence the brightness of, the electroluminescent layer. By suitable design, and choice of characteristic for the photoconducting and electroluminescent layers, it is claimed that a faithful reproduction of the incident picture can be produced at greatly increased luminance. The purpose of the opaque screen shown in Fig. 8*a* is to prevent feedback of light from the electroluminescent to the photoconducting layer, which would otherwise result in the device becoming self-sustaining.

The photoconductor most commonly used for this type of amplifier is cadmium sulphide, which is prepared in powder form by techniques not dissimilar to those used for electroluminescent zinc-sulphide phosphors. Although this substance's photoconducting properties have been known for many years, it is only recently that its sensitivity and stability have been sufficiently developed for practical use.

Another type of light amplifier studied in the United States is shown diagrammatically in Fig. 8*b*. Here the essential material is a thin evaporated film of manganese-activated zinc sulphide, to which a d.c. field can be applied. A picture is projected onto this film using an ultra-violet source. With no field present, a weak luminescent image is produced. Application of the field induces a marked increase in luminance of this image, and it is claimed that under optimum conditions 15 photons of visible radiation are emitted for each photon of incident ultra-violet radiation. Both types of light amplifier described suffer from the disadvantage of a long response and decay time, which makes impossible the presentation of motion pictures at normal cinematograph and television frame repetition rates.

Another possible application of the class of light amplifier shown in Fig. 8*a* arises from the good response of photoconducting cadmium sulphide to excitation by X-rays. If a beam of X-rays instead of visible radiation is incident on the light amplifier, its intensity pattern will be faithfully reproduced as a visible picture by the electroluminescent layer. This could be observed visually or photographed in much the same way as a normal fluorescent X-ray intensifying screen. By suitable design, such an electroluminescent intensifying screen could be made many times more sensitive than the conventional article, and result in a considerable reduction in the present X-ray dosage. Since X-rays are mostly used to reveal static or slow-moving objects, the relatively slow response of an electroluminescent X-ray intensifier is not likely to be a serious limitation.

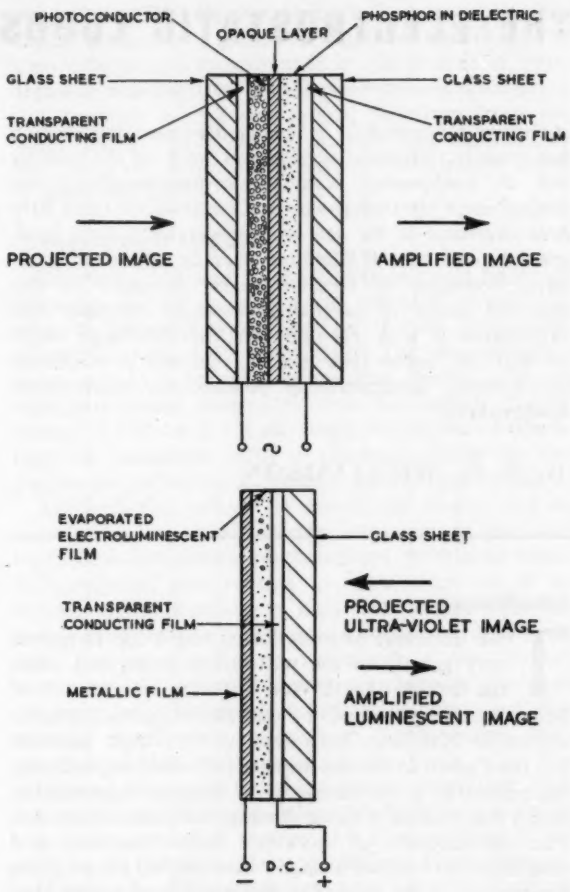
It will be realized that light amplifiers for the display

of television pictures require some form of television tube and lens system to project the primary picture. Although a picture of only relatively low luminosity is required, the necessary equipment to produce it is costly. Many ingenious ways have, therefore, been suggested for displaying the picture information by direct excitation of an electroluminescent screen using systems of conductors; for example, parallel strips deposited on each side of the screen and energized in a predetermined sequence. No solution has so far been found to the truly formidable commutation problems involved, but success would enable the picture projection system to be dispensed with. That is to say, the whole television receiver would consist of a screen about 2 cm thick, attached to the wall, and operated by means of a multiple cable from a separate supply unit.

The scheme just mentioned, of employing a set of narrow conducting strips on each side of an electroluminescent cell, is ideally suited to the indication of successive positions on a surface, such as is required in some map plotting techniques. For a display in terms of Cartesian co-ordinates, the sets of strips are arranged mutually at right angles, and a pair of strips, one from each side, is energized to give a spot of light at the cross-over point. Owing to the shunting effect of the unenergized strips, the whole of each energized strip is to some extent luminescent, producing two illuminated lines across the device with a bright spot at the cross-over point. The arrangement need not be confined to Cartesian co-ordinates and could for example be as readily applied to two intersecting systems of hyperbolas.

Another application of electroluminescence to electronics is in storage devices, and other complex switching networks. In Fig. 7, it will be evident that if the light from the electroluminescent element is able to fall on the photoconducting element, optical feedback will keep the system in a conducting state until the supply is removed. That is, the original pulse of light which stimulated the system is stored. In practice, the electroluminescent and photoconducting elements are combined in a single cell which can be made very compact—less than a ½-inch cube. One way of many in which this principle may be applied is to interconnect a small group of cells to form a network which passes an incoming signal only when the network has already been energized by an earlier signal, the unit reverting to an unenergized state ready for the next energizing signal.

Many systems that will perform this function have been devised, but it would seem that the electroluminescent switching cell has something to offer on the score of low cost, small size and simplicity of construction. Owing to their rather long response and decay time, however, they are likely to be limited to devices in which switching times of not less than 1 millisec duration are acceptable.



8 *Construction of electroluminescent light amplifiers*

The thickness is greatly exaggerated.
a Photoconducting type. **b** Field-enhanced type.

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THE ELECTROSTATIC LOUDSPEAKER

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A growing public interest in high-quality sound reproduction has recently stimulated development work on the weakest link, the loudspeaker. Many of the disadvantages of the limited-range electromagnetic and electrostatic types have been overcome in the new wide-range electrostatic loudspeaker, and Mr. Williamson gives an appraisal of the latest technique of constant-charge operation in this objective survey of general advances in the field. Mr. Williamson is with Ferranti Ltd., at Edinburgh where he was for some time engaged on electro-acoustical development, particularly of pickups and electrostatic loudspeakers.

D. T. N. WILLIAMSON

Introduction

THE technique of reproducing sound has improved very greatly in the past thirty years, and, since the Second World War, with the introduction of better recording methods on disc and magnetic tape, the attainable standards have become very high. Impetus has been given to the development of sound-reproducing equipment by a recrudescence of musical appreciation, which has created a rising demand for such equipment. The development of pickups, radio receivers and amplifiers has reached a stage where they no longer place limitations on the quality of the reproduced sound; but this cannot be said of the loudspeaker, which is still by far the weakest link in the sound-reproducing chain.

The only type of loudspeaker which is at present in large-scale use is the moving-coil-driven cone unit, the basic design technique of which was laid down in 1925 by Rice and Kellogg[1] and has not since been substantially improved. On the other hand, there have been a large number of detailed improvements, generally arrived at by a development process of 'cut and try', which has tended to give the impression that loudspeaker manufacture has more in common with the arts than with the sciences. Improvements in coil and cone design and materials, the addition of further cones driven from the same coil or a section of it, post-war improvements in magnetic materials (which have allowed high flux-densities to be used with improvement to the efficiency and damping), and improved loudspeaker enclosures have all contributed to a steady increase in the standard of reproduction which could be obtained from such units.

Always, however, there has been the basic limitation that a cone can only radiate even approximately uniformly over the audible spectrum because of resonances, and the design technique has been an attempt to place these resonances at strategic positions. The physical difficulty of making cones much larger than 15 in. in diameter limits the power levels which can be radiated at low frequencies, owing to poor acoustic loading. Such units cannot simultaneously handle frequencies at the other end of the spectrum without severe focusing. This has led to the use of a multiplicity of units, each designed to handle a portion of the spectrum, and most high-quality moving-coil loudspeakers are of this type. It has long been clear that these techniques are approaching their asymptote, and that little further possibility of improvement exists.

The Electrostatic Transducer

Another type of electro-acoustic transducer received considerable attention, especially in Germany during the period from 1920 to 1935, with little tangible result, except for a flood of patent literature. This was the electrostatic loudspeaker, in which a conducting membrane or diaphragm was caused to move by the electric force produced between it and a sound-translucent stationary electrode by the application of a potential difference between them.

This method has always appeared attractive because the actuating force is distributed uniformly over the diaphragm, all parts of which can be made to move uniformly in phase. There is, therefore, no physical limit to the area of such a loudspeaker, and it can be produced with plane or curved surfaces to give any desired radiation characteristic.

Until recently electrostatic transducers were regarded as inherently non-linear devices, because, with all the arrangements hitherto, the relationship between the force, electrode spacing and potential difference between the electrodes, was an inverse square law. Even with the use of a high polarizing potential, this meant that the amount of diaphragm movement, expressed as a fraction of the initial electrode spacing, was limited to a low value by the onset of waveform distortion, as also was the allowable ratio of the signal and polarizing voltages. The value of the polarizing voltage, and hence the efficiency, was limited by ionization and the likelihood of destructive sparking.

Design Limitations

It follows from these limitations that an electrostatic loudspeaker must have a large surface area, or be confined to the radiation of high frequencies only, or that it must be very inefficient; and all the earlier work was guided and shaped by the acceptance of this apparently incontrovertible dictum. A very large area was required, because the small diaphragm amplitude which was permissible placed a restriction on the radiated power per unit area. In order to radiate acoustic power of the order of 0·1 watt at low frequencies, this being the

minimum requirement for satisfactory domestic sound reproduction, a surface area of many square feet was essential. The alternative of increased electrode spacing carried with it the penalties of decreased efficiency and the difficulties and dangers associated with the use of very high polarizing and signal voltages.

The Ideal Loudspeaker

The constructional, acoustical and economic difficulties associated with large-area radiators effectively confined the electrostatic loudspeaker to high-frequency applications until the developments of recent years. There is no record of the existence of a wide-range electrostatic unit before 1950, although a large-area loudspeaker, radiating low energy per unit area, is probably inherently the most satisfactory construction for a loudspeaker, because of the naturally high acoustic loading and wide sound source. The conversion of one wall of a room into a sound radiator, the opposite wall being rendered as nearly totally absorbent as possible, is probably the only complete solution to the problem of obtrusive room acoustics in high-level domestic sound reproduction, because the observer is then 'immersed' in a uniform sound field, substantially free from standing waves. Experiments at Huntingdon and Edinburgh with large-area sound sources have tended to confirm the high expectations of performance which such a source would give.[2]

Early Development

From a study of the numerous patents taken out between 1920 and 1940, it is clear that a great deal of ingenuity was shown by designers in Germany, the United States and Great Britain, and that many of the detailed improvements which contributed to the performance of the present-day wide-range linear electrostatic loudspeaker were considered by earlier workers, but never in the context which would have enabled them to overcome their most fundamental obstacle—poor linearity.

The simplest form of electrostatic loudspeaker consists of a conducting diaphragm spaced from a perforated stationary electrode by an insulating plastic film, forming a parallel-plate capacitor. The signal and polarizing voltages are applied in series to the two electrodes, and it is usual to combine the moving electrode and the insulating film by sputtering a metallic film on the side of the insulating film remote from the stationary electrode. Such a transducer must necessarily have a high mechanical diaphragm stiffness in order to achieve stability with the high negative stiffness produced by the electric field. This mechanical stiffness is produced by the correct choice of plastic film and by shaping the perforations so that the plastic deforms into dimpled holes. Such transducers are limited to the reproduction of high frequencies.

One of the devices most frequently suggested was the use of a double-sided or 'push-pull' arrangement to apply a symmetrical force to the diaphragm. This has the effect of cancelling the even terms in the power series in a similar fashion to a push-pull amplifier, and enables a greater diaphragm movement to be obtained for a given degree of non-linearity, but the improvement is not great and does not permit any radical departure from the design limitations already discussed. This method has been proposed in various guises, the most recent being in September 1956.[3]

Constant-Charge Operation

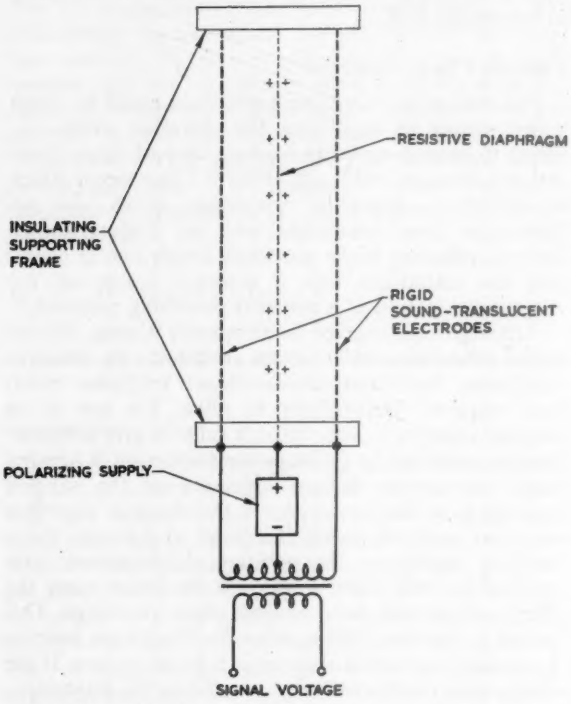
The realization that these restrictions could be swept away, simply by modifying the operating conditions, seems to have occurred to workers on both sides of the Atlantic between 1952 and 1954.[2,4] The concept which converted a supposedly non-linear device into an inherently linear transducer with the highest known intrinsic efficiency is the startlingly simple one of operating the transducer with a constant charge on the diaphragm, instead of a constant polarizing potential.

Although this concept is deceptively simple, like so many other apparently simple inventions its practical realization introduces constructional problems which have required great efforts to solve. The use of an external charging resistor of high value to give constant-charge conditions to a conducting diaphragm is impractical, because the leakage resistance of the support material is of the same order as the charging resistance necessary, and this makes it difficult to maintain stable working conditions. In addition, loudspeakers constructed on this basis would not be linear when the diaphragm motion departed from plane translation. This occurs at low frequencies, when the diaphragm bows in a catenary, instead of moving as a plane surface. If the charge were free to redistribute itself over the diaphragm, as it would be if the diaphragm were highly conductive, the potential over the surface would be equalized; the conditions then would no longer be those of constant charge per unit area, and non-linearity would occur.

To obviate this, the resistivity of the diaphragm material itself must be made sufficiently high for the charge, with its associated capacitance, to be unable to migrate along the surface during the period of the lowest frequency it is required to reproduce.

Although a rigid explanation of the theory of constant-charge operation is lengthy, and has been given elsewhere,[2,4] a quite accurate mental picture of the behaviour of the loudspeaker can be obtained if it is considered as consisting of a substantially insulating diaphragm of thin plastic suspended in the gap between two perforated electrodes, as shown in Fig. 1. The diaphragm is so thin that it produces negligible disturbance of any field configuration in the gap, and it can be considered in operation as behaving like a sheet of charged particles. The charge on the diaphragm produces a field in the gap which varies with the position of the diaphragm and has the effect of producing a linear negative compliance which partially counteracts the natural stiffness of the diaphragm. In order to avoid instability, the value of this negative compliance must always be less than the positive

compliance. If now a signal voltage is applied between the outer plates, the diaphragm experiences a force which is the summation of the product of the unit charges upon it and the field strength in the gap due to the signal voltage, and this force is clearly independent of the position of the diaphragm in the gap.



1 *The constant-charge electrostatic loudspeaker*

True and Apparent Efficiency

Electrostatic loudspeakers have a high intrinsic conversion efficiency—in fact they are the most efficient transducers in existence. Their only losses are dielectric losses in the electric field in the gap, and heat generated in the diaphragm due to imperfect elasticity. Since the dielectric is usually air and the diaphragm flexure is exceedingly small, these losses are negligible and conversion efficiency approaching 100% is theoretically possible.

The impedance of an electrostatic loudspeaker consists, ideally, of a capacitance in parallel with the radiation resistance. If the air load on the diaphragm is, as is usually the case, not purely resistive, the parallel impedance will be modified accordingly. This impedance, however, is swamped by the reactance of the static capacitance between the fixed plates, and it is this which limits the realization of a high efficiency at other than a single frequency, because the sources of signal energy which are at present available have internal impedances which are primarily resistive. If an attempt is made to drive the loudspeaker over a range of frequencies, as is necessary for the reproduction of music, the circulating reactive power in the loudspeaker capacitance produces considerable loss in the source impedance of the driving amplifier, which, even with optimum design, has the effect of reducing the apparent efficiency to the order of 5% or less; *apparent efficiency* is defined as the ratio of the acoustic power (in watts) to the amplifier output (in volt-amperes) necessary to provide the required voltage across the loudspeaker capacitance. Apparent efficiency and bandwidth are interrelated, and one can always be increased at the expense of the other. If the apparent efficiency is limited to the order of 5%, the available bandwidth is 4–5 octaves.

The development of a signal source, the internal impedance of which was capacitive, would enable the true efficiency to be realized, and this is not beyond the bounds of possibility. Another method which can be used to increase the efficiency with some configurations of loudspeaker is to divide the total area into a number of sections and to connect these sections together by means of inductors so that an electromagnetic delay line is formed, the capacitive elements being the loudspeaker sections, and each capacitor being shunted by the reflected mechanical and acoustical impedance of that particular unit. If the cut-off frequency of this delay line is arranged to be higher than the highest frequency if is desired to reproduce, and the line has a sufficiently large number of sections, preferably being tapered in impedance to maintain a constant voltage across each section in spite of the dissipation in the line, quite high efficiencies can be obtained, and of course the input impedance becomes predominantly resistive. The wavefront from the complete radiator is tilted with respect to the plane of the loudspeaker by the delay, but this is not a disadvantage, and can even be turned to good account.

Another method, which enables compact loudspeakers to be constructed, is to design the loudspeaker so that it consists of a number of radiating elements each handling only a portion of the frequency spectrum to be reproduced, but forming in conjunction with its neighbours a sound source with a substantially uniform radiation characteristic over the whole frequency spectrum. Each of these units can then be matched optimally to the amplifier over its limited frequency range, the overall efficiency increasing as the number of sections is increased and the bandwidth of each section correspondingly decreased. To achieve uniform radiation over a large polar angle by this means is difficult and requires great technical competence: nevertheless it is a useful method of achieving first-class performance with reasonable dimensions and cost.

Conclusion

The use of constant-charge electrostatic principles enables electrostatic loudspeakers to be designed with completely predictable characteristics to cover any desired range of the audible spectrum. The first wide-range unit to be designed commercially (Fig. 2) covers

Acoustical Manufacturing Co.

2 *A wide-range electrostatic loudspeaker*

the frequency range 45–18 000 c/s with a uniformity of ±3 dB. It introduces negligible distortion within this range at a sound level of 95 phons in an enclosure of 5000 ft³ with average reverberation. This loudspeaker is of twin-element cabinetless construction, measuring 34 in. × 28 in. × 7 in. and has a flat 'fire-screen' appearance. The impedance is 30–15 ohms in the range 40–8 000 c/s, falling above 8 000 c/s.

Two loudspeakers available in the United States are for h.f. radiation only, and are intended to supplement conventional electromagnetic l.f. radiators. One covers the range above 500 c/s, and the other above 2000 c/s. Accurate performance data are not available.

With the design principles now established, the range and performance of electrostatic loudspeakers are determined almost entirely by the allowable size and cost. For all normal requirements they allow a much superior level of performance to be achieved than is possible with electromagnetic loudspeakers and at lower cost. Because of this, they are certain to displace the latter during the next few years in high-quality sound-reproducing equipment.

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Irradiated Polythene Dielectric

After a long period of investigation into the effects of high-energy radiation on the physical and electrical properties of polythene, a new type of insulated wire has been developed and is in limited manufacture. The experiments were basically simple: formulations of normal polythene and chemical modifying agents were exposed to high-velocity electron bombardment by a Van de Graaff 2 MeV particle accelerator.

Examination revealed that the dielectric properties of the original product were unimpaired and that, owing to the molecular cross-linking in the material that occurs during irradiation, the maximum continuous operating temperature has risen from about 85°C to 100°C with a short-term operating temperature around 150°C.

The implications of this development when applied to the manufacture of wiring and cables are considerable. Soldering, for example, may be carried out right down to the insulation, and irradiated polythene cable may now be used for applications where high external temperatures are experienced. In addition momentary overloads which were formerly responsible for damaging or destroying the insulation are made harmless, for irradiated polythene does not melt when exposed to higher temperatures, but is converted to a rubber-like substance which retains some useful strength up to a temperature of 450°C.

The new material provides a valuable supplement to existing methods of sleeving and encapsulation. Extruded sleeving with an inside diameter of $\frac{1}{8}$ inch, when irradiated, can be cold distorted to an inside diameter of $\frac{1}{4}$ inch or more to fit over terminals or components. Upon momentary reheating to between 135°C and 150°C it attempts to return to its original $\frac{1}{8}$-inch inside diameter and thus encapsulates the component or terminal.

Before the actual irradiation process, the polythene and its modifying agent are extruded onto the conductor in the conventional way and reeled up on a spool. The latter is then attached to a rig which pays off the wire through the concrete shield of the irradiation chamber and beneath the electron beam emitted by the accelerator. By using a simple system of rollers, the wire is passed through the beam so that all sections of the insulation receive the same integrated dose of radiation. The shielding effect of the conductor is counteracted by revolving the wire on its own axis to expose each area equally.

The following table gives a comparison of some of the properties of a grade of normal and a grade of irradiated polythene.

	Normal polythene (Grade 7)	Irradiated polythene (low dose)
Tensile strength, lb/in²	1 500	2 400
Elongation at break, %	500	550
Mechanical creep ..		Less than normal polythene
Stiffness	Melts at 115°C	Converted to soft rubber-like substance at 115°C
Coefficient of expansion		No change
Acid and alkali resistance	Completely charred in boiling sulphuric acid at 60°C	Surface attack only in boiling sulphuric acid at 60°C
Oxidation rate ..		No change
Resistance to environmental stress cracking	Subject to cracking when stressed in presence of certain active agents	Complete immunity
Solvent absorption ..	Dissolves at high temperatures in certain solvents	Swelling only in similar solvents
Power factor	0·000 15–0·000 25	0·000 25–0·000 35
Dielectric constant ..	2·3	2·3
Volume resistivity ..	Greater than 10^{15} ohm-m	Greater than 10^{15} ohm-m

SHORT REVIEWS OF PAPERS

Series Capacitors in Transmission Lines

A short review of a Supply Section paper (No. 2252) entitled 'Voltage Performance of Series Capacitors in Transmission and Distribution Lines', by J. M. Magowan, Associate Member. The paper was published individually in January 1957, and it will be republished in Part A of the Proceedings. The author is with the Electricity Supply Commission, Southern Rhodesia.

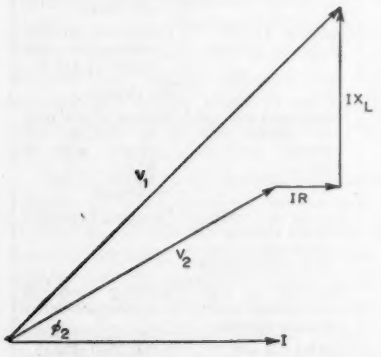
WHEN TRANSMISSION AND DISTRIBUTION LINES OPERATE AT a power factor determined chiefly by the useful load supplied, the permissible voltage drop is a limitation on power transfer.

With such lines susceptance is usually negligible, and the voltage drop in a line of resistance R and reactance X_L, supplying a load having a phase displacement ϕ_2, is given with reasonable accuracy by the addition of the resistive component $R\cos\phi_2$ and the reactive component $X_L\sin\phi_2$. The receiving voltage at the end of such a line is shown vectorially in Fig. 1.

Capacitors shunting load centres reduce the phase displacement, and while the resistive component of voltage drop remains unaltered the reactive component is reduced; it becomes zero when a power factor of unity is achieved and negative at leading power factors. Unless switched in sympathy with load reactive current or with receiving voltage, shunt capacitors do not improve line-voltage regulation.

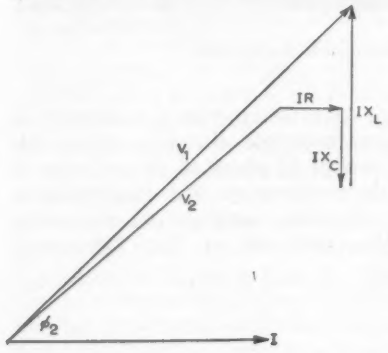
Capacitors in series with lines compensate for the line reactance and reduce the reactive component of voltage drop as shown in Fig. 2. When series-capacitor reactance exceeds line reactance the boost occurring will also compensate, partially or wholly, for the resistive component of voltage drop. This is achieved without increase in line current, and consequently line loss, as would be the case with shunt capacitors.

The chief merit of series capacitors lies in the fact that voltage boost due to them is dependent on the reactive component of line current. They thus improve line-voltage regulation automatically and within 5 millisec, which is much quicker than any other commonly used method of automatic line-voltage regulation.



1 *Receiving voltage for line without series capacitors*

V_1 is the sending voltage. V_2 is the receiving voltage. ϕ_2 is the line power factor.



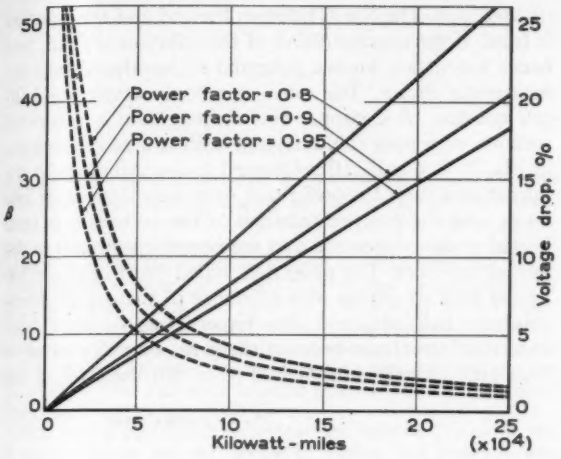
2 *Receiving voltage for line with series capacitors*

The boost from both shunt and series capacitors depends on their reactive-power rating, and Fig. 3 indicates the ratio β of shunt-capacitor rating to series-capacitor rating, for equivalent voltage boost in a 33 kV line having a 0·075-inch² conductor with 78-inch spacing, for varying kilowatt-mileage.

It will be noted that the ratio remains constant for a given kilowatt-mile loading whether light loads are supplied over long lines or heavy loads over short lines.

In Southern Rhodesia the Electricity Supply Commission has, in recent years, given active consideration to the use of series capacitors in certain of its lines, where for various reasons it was not possible to overcome voltage-drop conditions by the more usual methods of employing higher voltages or reconstruction using larger conductors.

The first installation was brought into service early in 1953. This was for use with an 11 kV 0·05-inch² conductor line some 40 miles in length serving a mining area where the load had increased rapidly. The installation was of an experimental nature and possessed a reactive power of



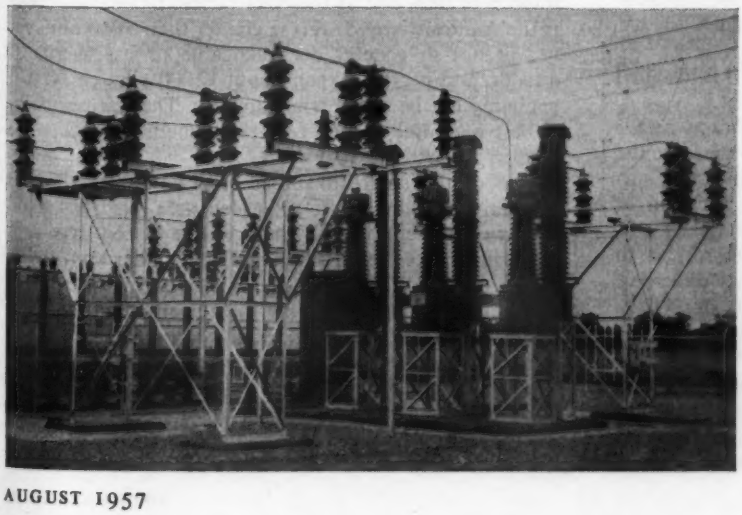
3 *Ratio of shunt- to series-capacitor rating for equivalent voltage boost*

The dashed curves represent the ratio β. The full curves represent the voltage drop.

123 kVAr. Voltage charts before and after the installation of the capacitor revealed an improvement in effective voltage regulation in excess of 15%, of which almost half could be attributed to the series capacitor alone, and the balance to the fact that the installation enabled further improvement to be gained from automatic on-load tap-changing transformers in the circuit.

In 1956 an installation of particular interest was made in a line supplying a sawmill as its chief load. The reactance of the 0·025-inch² line was over-compensated to the extent of 320%. This resulted in compensation of a large part of the resistive, as well as full compensation of the reactive, component of voltage drop.

4 *Part of a 6000 kVAr series-capacitor installation on an 88 kV transmission line*



In view of the fact that the 330 kV transmission system associated with the Kariba hydro-electric project would not be operating in Southern Rhodesia before 1961, it was necessary to increase the power transfer over an existing major 88 kV transmission line between Umniati generating station and Norton—a distance of 90 miles. This resulted in a series-capacitor installation totalling 6000 kVAr. A part of this installation is shown in Fig. 4. Within the limits of acceptable voltage drop the current-carrying capacity of this line was increased by 100%.

621.319.4 : 621.315.1

Cathodic Protection

A short review of a paper (No. 2336) with the above title by L. B. Hobgen, O.B.E., M.I.Mech.E., Member, K. A. Spencer, B.Sc.Tech., and P. W. Heselgrave, B.Sc. The paper was published individually in February 1957, and it is republished this month in Part A of the Proceedings. Mr. Hobgen is with the Air Ministry, and Mr. Spencer and Mr. Heselgrave are with Spencer and Partners.

IN ORDER TO MITIGATE THE CORROSION OF BURIED structures, such as pipelines and telephone and power cables, or structures partly immersed in water, such as jetties or ships' hulls, a method known as cathodic protection has been evolved. The method is not new, being applied to ships' hulls over a hundred years ago, but the application to buried pipes and cables has come into widespread use only during the last thirty years.

Corrosion is associated with the flow of direct currents, whether self-generated by electrochemical action or from an external source. The corrosion occurs at points said to be anodic, where positive current flows from the buried structure into the electrolyte, i.e. soil or water, but does not occur at points said to be cathodic, where the current returns to the buried structure.

Cathodic protection consists in making conditions such that the whole of the metallic structure to be protected receives current from some external source and is thus made entirely cathodic.

Cathodic protection cannot replace metal that has already been corroded away, and, in fact, when applied to badly pitted pipes, it may cause a series of leaks to occur for the first few weeks as the polarizing film of hydrogen formed at the surface of the metal by the protective current reduces or displaces scale and corrosion products. Cathodic protection will, however, prevent further corrosion taking place.

There are two ways of supplying current to the structure, the first is by

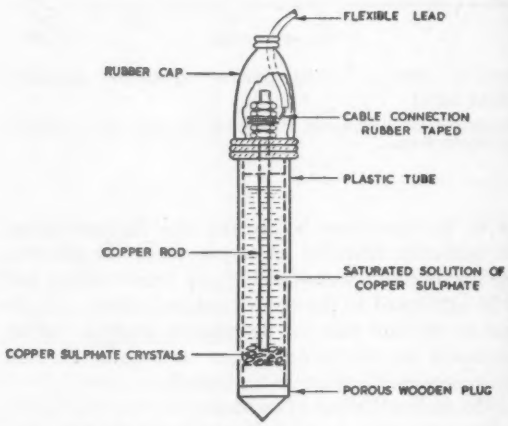
sacrificial anodes and the second by power-impressed currents. The first method consists of connecting to the structure blocks of metal which are more electronegative than the metal of the structure and immersing them in the common electrolyte. Magnesium is the metal generally used, but because of the low effective driving voltage it can be employed only in soils of low resistance or in sea-water. The second method is rapidly replacing the sacrificial-anode type for almost every application. It consists in supplying direct current to an anode of graphite rods or scrap iron called a ground bed and letting the current find its way to the unprotected parts of the buried structure and thence back to the source of supply. If there is an a.c. supply in the vicinity the most convenient method is to use a transformer rectifier. The positive terminal of the rectifier is connected to the ground bed by a well-insulated cable and the negative terminal to the structure to be protected.

1 *Small 5 amp transformer rectifier at Aden*

The small transformer rectifier shown in Fig. 1 is installed for protecting buried lines in a chemical plant.

The only ready means of comparing conditions before and after cathodic protection is applied is to measure the potential between the buried structure and the surrounding electrolyte. In general a natural potential of −0·3 to −0·7 volt exists between the metal and surrounding soil, the metal being negative with respect to the soil. To prevent corrosion this potential difference must be increased to at least −0·85 volt, or −0·95 where sulphate-reducing bacteria are present in the soil.

To take these measurements a very-high-resistance voltmeter is used in conjunction with a device known as a half-cell. In cathodic protection practice, the half-cell consists of a pure metal rod dipping into a solution of its own ions. The e.m.f. between the rod and the solution is fixed, if the concentration of the solution is fixed, and hence a constant known potential is introduced into the measuring circuit. The most commonly employed half-cell consists of a copper rod dipping into a saturated solution of copper sulphate, and is illustrated in one form in Fig. 2. The half-cell is inserted in the soil close to the buried structure, for preference only a centimetre or two away, and the positive terminal of the voltmeter is connected to the copper rod and the negative terminal to the buried structure. The potentials stated previously are for buried steel structures with reference to a copper/copper-sulphate half-cell, and the paper mostly deals with mild-steel structures because the great majority of pipelines and jetties are fabricated from this material. If the



2 *Copper/copper-sulphate half-cell*

buried structure is lead, the potential between the metal and soil must be more negative than −0·55 volt measured against the copper/copper-sulphate half-cell.

When deciding whether or not cathodic protection is to be provided, one of the chief factors to be considered is the soil resistivity. If this is greater than 3000 ohm-cm it will not in general be practicable to use sacrificial anodes, and if greater than about 12000 ohm-cm, it will probably not be worth while anyway. The soil resistivity is best measured by the four-point method spacing the rods in a line about 10 ft apart.

One of the chief difficulties in designing a cathodic protection scheme for a congested area such as an oil refinery is the effect it may have on the buried structures of local services, e.g. water, gas, telephone and power cables. If any or all of these structures are found to have anodic points or areas owing to the cathodic protection system, they can usually be made cathodic by bonding to the protected structure at suitable points.

The authors deal with this matter in some detail in their paper, and with the various applications of cathodic protection and the general economies affecting its use.

620.197.5

OBITUARY

LESLIE WALTER BALLARD

Leslie Walter Ballard, who died on the 1st September 1955, was born at Bournemouth on the 24th September 1885, the fourth child of a family of nine. He was educated at Dunheved College, Launceston, where he showed athletic prowess, and at Faraday House, of which Dr. Alexander Russell was then head. His works training was undertaken in 1905–7 at Willans and Robinson at Rugby, and at the General Electric Co. at Witton. In September 1907 he was appointed Chief Assistant in the Contract Department of the latter company and in 1910 was promoted to Chief Assistant to the Works Manager. In the following year he took up the position of Chief Technical Assistant Engineer with the consulting engineering firm of May and Hawes.

War service intervened; he attained the rank of Captain in the Royal Engineers and saw service in France and Mesopotamia. Returning to civilian life in 1919, he continued his consulting work with Messrs. May and Hawes, and became a Partner in the firm in 1923. He was engaged upon the preparation of plans, specifications and estimates for many electricity supply schemes throughout the country, and the supervision of contracts. When the firm closed in 1942, he obtained an appointment with the Ministry of Supply until his retirement to Sidford, Devon, in 1950.

Mr. Ballard was particularly interested in any Christian activity, including the Y.M.C.A. and youth centres. He leaves a widow and two daughters.

He joined The Institution as an Associate Member in 1913 and was elected a Member in 1924. T. C. N.

PHILIP VASSAR HUNTER

Philip Vassar Hunter, C.B.E., who died on the 22nd October 1956, was born at Emneth Hungate, in Norfolk, on the 3rd August 1883. He was educated at Wisbech Grammar School, and at Faraday House, where he obtained his diploma with first-class honours. After a period of training with Robert Hammond, the well-known consulting engineer, he joined in 1904 the staff of Merz and McLellan, with whom he remained for 15 years. In 1909 he succeeded Bernard Price as head of the Electrical Department.

Merz–Price protection had just been invented and this led to a revolution in the design of high-voltage systems in which Hunter took a leading part, making various inventions of his own such as the split-conductor and 4-conductor protective systems. When Price went to South Africa in 1909, Hunter took over most of his work and under his leadership much pioneer development was done on high-voltage switchgear, cables, overhead lines and large power stations.

During the 1914–18 War he was lent to the Admiralty, where he was one of the team of three who developed the Asdic submarine detector. For his part in this work he was appointed a C.B.E. in 1920.

In 1919, at the invitation of Sir Tom Callender, he joined Callender's Cable and Construction Co. Here, as Chief Engineer and Joint Manager, and later as a Director, he devoted his energies to the development of power cables. The wide scope of his work during his period with the Callender's Cable Co. ranged from pre-occupation, in 1920, with the development of 33 kV cables to sponsoring, in 1943, the world's first 3-core cable for 132 kV, and the invention of the buoyant cable used for sweeping magnetic mines. He initiated the company's Wood Lane Laboratories in 1934, and maintained his interest in them until his death.

In 1946, on the merging of Callender's Cable Co. with B.I. Cables Ltd., he became Engineer-in-Chief to British Insulated Callender's Cables, a post which he retained till 1948. From 1947 to 1952 he was Joint Deputy Chairman of the new Company. He also served on the boards of many other electrical companies.

As a sportsman he was in his younger days a keen skater and curler; in 1935, after some years as Secretary and Treasurer, he became President of the British Ice Hockey Association. He was well known as an enthusiastic golfer, and was Chairman of Addington Golf Club, of which he was for some years Captain.

He had a high reputation, both in his own country and internationally, for he had, to an outstanding degree, the ability to select the vital and essential facts from a complex situation, and having done so, to express his views with clarity and decisiveness. This gift of his was almost legendary; and many a harassed committee has been grateful for it.

He possessed in the highest degree the quality of leadership, selecting his lieutenants with care and judgment, trusting them with a high degree of individual responsibility and helping them, not only with wise advice but with unfailing support.

Yet, although he was a man of compelling personality, he would never use it to beat down opposition. Indeed, one of his greatest pleasures was to stimulate discussion; and his junior engineers gratefully recognized that their opinions would always be received with courtesy and understanding, so long as they were to the point, and honestly held. Quick to detect promise in his juniors, he took every opportunity of fostering their ability and helping them to greater responsibility in their profession.

His imperturbability was one of his notable characteristics. He steadfastly refused to be diverted from the work in hand, whether by present danger or by apprehensions as to the future, and those of us who remember him in the dark days of 1940 will always recall with gratitude the steadying influence he exerted on all those who worked with him in those difficult times.

This imperturbable attitude of mind was fundamental. He was a man of astonishingly equable temper; courteous, tolerant, and disdainful of provocation and malice. Few ever saw him angry; but, for him, the two cardinal sins were deceit and disloyalty, and these alone could evoke a blaze of wrath, as devastating as it was unwonted. In Philip Hunter's eyes, to confess an error was to be absolved. His quiet strictures were the more impressive because of their very mildness; and, once forgiven, the delinquent could rely—and knew he could rely—on 'P.V.'s' loyal support and help in retrieving his error.

He joined The Institution as a Student in 1902, and was elected an Associate Member in 1910 and a Member in 1914. He was a Vice-President 1928–31, President 1933–34, and in 1951 achieved the final distinction of Honorary Membership. He was a Member of Council and numerous Institution and other committees for many years. He served on the Newcastle Local Section Committee (later the North-Eastern Centre) 1911–13, and was a Vice-Chairman of the Committee 1913–14, and Chairman 1914–16. He was elected Chairman of the National Register of Electrical Installation Contractors in 1925; of the Wiring Regulations Committee, of which he had been a member since 1920, in 1934; of the Aircraft Electrical Equipment Committee in 1944; of the Model Form of General Conditions of Contract Committee in 1946; of the Codes of Practice for Earthing Committee in 1947; of the Joint Committee of Model Form of General Conditions of Contract in 1948; and of the newly-formed National Inspection Council for Electrical Installation Contracting in May 1956. He remained Chairman of these committees until his death. He also served on the Codes of Practice Committee for Electrical Equipment of Buildings 1943–54, the Library and Museum Committee 1950–51, the Research Committee 1950–51, and the Codes of Practice Committee for Electrical Engineering from 1954. He was President of the Electrical Industries Benevolent Association 1939–41. In 1933 he was elected a Fellow of the American Institute of Electrical Engineers.

His name will endure as one of the great engineers of his time.

His name was known and honoured far beyond the bounds of his own country; and on his passing the national and international councils on which he served so long and with such distinction lost a wise, respected and well-liked colleague. J. T. H.

FRANK COATES

Frank Coates, who died on the 15th June 1956, was born on the 25th February 1880. He was educated at Crypt Grammar School in Gloucester, and served a three years' apprenticeship with W. H. Heath and Co., Electrical Machine Manufacturers, Birmingham, during which time he studied electrical engineering part-time at Birmingham Technical School.

In 1899 he went to Reyrolle's works in London, continuing his studies under Silvanus P. Thompson, and at the age of 20 was sent to Tyneside to superintend the installation of switchgear and cables at the Neptune Bank power station. In the following year he was appointed Manager of the new Reyrolle factory established at Hebburn. Later, when the London section of the Reyrolle works was transferred to Hebburn, Mr. Coates took charge of the drawing offices, and subsequently became responsible for all research and development, remaining in this position until his retirement in 1945. He was elected a Director of the company in 1927 and served in that capacity for nearly twenty years.

Frank Coates was a straightforward and utterly unpretentious man. At work, his attitude expressed the sense of duty for which his generation was disciplined; but apparent severity covered shyness and much kindness. He had a flair for spotting a weakness in a train of mechanism, and an equal flair for spotting a weakness in a long-winded argument.

His family life was a happy one—he is survived by his widow, two sons and a daughter. Throughout the ten years of his retirement he enjoyed excellent health and was a busy man in a large garden, most of which he himself had laid out. Having all his life been interested in world sources of energy, he took advantage of leisure to keep informed of the developments in this field, particularly in the possibilities of using nuclear energy.

Frank Coates joined The Institution as an Associate Member in 1912, and was elected a Member in 1927. J. C.

HENRY CHARLES EDWARD JACOBY

The death at the age of 88 years of Henry Charles Edward Jacoby on the 9th April 1957 terminated the career of a remarkably productive development engineer.

Mr. Jacoby had a very hard youth. An elder sister gave him his early lessons, but he had largely to teach himself in the following period, while working at the same time on the land for his living. He received his practical training as a student at M. Immisch and Co., London, from 1886 to 1891, during which time he took an electrical engineering course at the Regent Street Polytechnic and studied part-time at Finsbury Technical College. Later, at the City and Guilds Technical College, he became a pupil of Silvanus P. Thompson, whose influence seems to have been decisive for his development. Mr. Jacoby appears to have contributed his own ideas on a.c. motors and these can be traced back to 1891. His early inventions, however, turned out to have been anticipated by others.

In 1891 he joined the General Power and Traction Co. as Chief Designer and Tester. From 1893 to 1907 he was a Partner and Director of a small firm, White Jacoby and Co., and was the designer of White-Jacoby dynamos and motors. In 1907 Mr. Jacoby became the Works Manager, and, later, Technical Director of the New British Electric Supply Co. During this period he designed, for instance, the swinging-curtain-type punkah, and a range of single-phase a.c. commutator motors, speed control of which was effected by a centrifugal governor operating a brush rocker mechanism. Later, he worked out complete designs for 3-phase series and shunt (Schrage) commutator motors up to 250h.p., which were successfully manufactured by Messrs. Witton James. He also became associated with the development of the first totally enclosed motors built in this country.

Years before the First World War some of his inventions and designs were used by the General Electric Company, the Development Laboratories of which he finally joined in 1929 when he was over 60 years old.

The work he either initiated or influenced decisively during the following 25 years involved such subjects as fractional horse-power and gramophone motors, automatic record changers, high-speed spinning motors, vacuum-cleaner design, etc., but he helped also in the design of a.c. commutator motors, in which he was a prominent expert in this country. He was 78 when he began designing automatic f.h.p.-motor armature-winding machines, a whole range of which is now in continuous use.

Mr. Jacoby had an unusual capacity to become completely absorbed by the problems confronting him or others, to whom he tried to be helpful with utter selflessness. His colleagues saw in him a most original thinker, and all who had any contact with him were impressed by the straightness of his character.

Even after his retirement at the age of 85 he continued actively as a consultant to the G.E.C., and worked on a paper about the design of Schrage motors until a few weeks before his death.

Outside his technical interests Mr. Jacoby appears to have been a keen bicyclist in his younger years, stretching back to the days of the penny-farthing bicycle. His main spare-time activity was, however, reading. He had a keen interest in philosophy. His tenacity in anything he undertook is exemplified by his unwillingness to give up driving his own car up to the age of 81. His will-power seemed to be unbeaten to the end. His capacity for creative work and independent thought lives on in his daughter and his son, to whom he was a model of a caring father, as he was a loving and beloved husband to his wife. The achievements of Mr. Jacoby have left behind a notable mark which survives him, even if the name of this super-modest man is not found in any annals of the development of electrical engineering.

He joined The Institution as a Member in 1918. E. F.

MAURICE ERNEST LABORDE

Maurice Ernest Laborde, ING.E.S.E., L.ÈS.SC., died on the 12th March 1957 at the tragically early age of 56 years, as the result of a motor accident. He was born in Constantine, Algeria, on the 17th August 1900, and received his education first at the Lycée de Constantine, Algeria, and later at the University of Algiers. After graduating as Licencié ès Sciences, in spite of the difficulties due to the First World War, he was for two years a professor of physics at the Lycée de Constantine. He then turned to engineering, taking the courses at the École Supérieure d'Électricité, Paris, where he brilliantly obtained his Engineer's Diploma in 1926. Throughout his career, Maurice Laborde never forgot this early educational training, which accounts for the great clarity of his statements.

He received his practical training at Nord-Lumière and in 1928 entered the Union d'Électricité as an Engineer; he remained with it until nationalization in 1946. He became in 1933 the Chief of the Study and Electrical Work Department, and was appointed Assistant Manager in 1941. He took part in the development of the Paris area 63kV and medium-voltage systems with the rational study of the substations, obtaining a high degree of security under excellent economic conditions. About the same time he contributed to the equipment of several important power plants in the Paris area and Massif Central, and to the development of the French 225kV interconnection system. In particular he took a very important part in the study and installation of the first French 225kV underground cable link, and his special interest in cables is well known.

When nationalization came, he was appointed Chief of the Service of System Equipment in the Studies and Research Department of Électricité de France and was the promoter of the Research and Testing Centre of Fontenay, of world-wide reputation, the main feature of which is the breaker-testing station directly connected to the 225kV system. In this centre important research work on insulated cables was carried out under his guidance. One of M. Laborde's last studies to which he devoted the minutest care for several years was the Cross-Channel Interconnection between France and England.

These engineering achievements were not the only interest in

M. Laborde's life. His early teaching experience was put to good use and in 1934 he became the Professor of Electrical Installation at his old school the École Supérieure d'Électricité, where he also took part in the work of the school's Board of Directors and followed very closely the development of the National Schools for Engineers in various large provincial towns. He possessed a very extensive culture and had a great liking for historical studies and also for music, being himself a brilliant performer.

Maurice Laborde was known internationally as a specialist in problems connected with breakers and underground and submarine cables. All those who had the privilege of meeting him appreciated his great kindness, integrity, and straightforwardness. He was a gentleman and was always most considerate to others. He is survived by a widow and three daughters.

He was a Knight in the Order of the Legion of Honour. He had been a Member of the French Electro-Technical Committee since 1938, and took a very active part in the work of the I.E.C., as Member of Technical Committee 17 (Switchgear and Control gear), and of the C.I.G.R.É., as Chairman of the Cable Committee and Member of the Switchgear Committee. He was President of the Société Française des Électriciens in 1951. In 1956 he was elected a Fellow of the American Institute of Electrical Engineers.

He published more than thirty reports or studies, some of which are in English. He was co-author with Mr. D. P. Sayers and Mr. F. J. Lane of a paper entitled 'The Possibility of a Cross-Channel Power Link between the British and French Supply Systems', which was read before The Institution in April 1954 and published in the *Proceedings* in September 1954. A John Hopkinson Premium was awarded to the authors.

He joined The Institution as an Associate Member in 1947 and was elected a Member in 1951. He had been Oversea Deputy Representative of the Council for France since 1949.

P. M. J. A.

JOHN KNOWLES IM THURN

Vice-Admiral John Knowles im Thurn, C.B., C.M.G., C.B.E., K.M. who died on the 5th July 1956, was born on the 7th March 1881. He entered H.M.S. *Britannia* at Dartmouth in 1895 as a naval cadet. Promoted to Lieutenant in 1902, he joined H.M.S. *Vernon* the following year to specialize in torpedoes and wireless, and from then on was closely connected with the growth and development of naval wireless and electronics. He was Fleet W/T Officer in the Home Fleet until 1913, when he was promoted to the rank of Commander. Early in the First World War he was W/T Commander in H.M.S. *Vernon*, and then became W/T Officer on the staff of Admiral Sir Charles Madden, Second-in-Command of the Grand Fleet.

In 1918, on promotion to Captain, he was appointed Assistant Director of the Electrical Section of the Department of Torpedoes and Mining at the Admiralty, and, when this section became the Signal Department in 1920, he became its first Director. As such, Captain im Thurn was responsible for all matters connected with the provision, organization and maintenance of wireless-telegraphy and radio-telephony. From 1921 to 1925 he commanded the cruiser *Ceres* in the Mediterranean and the battle-cruiser *Hood* in the Home Fleet. In the latter he made a cruise round the world with the Special Service Squadron in 1923–24, as Flag-Captain to Admiral Sir Frederick Field. This was followed by three years in command of the Signal School at Portsmouth, which included the W/T Experimental Department, and, until its transfer to Portland, the Asdic Experimental Department. On leaving the Signal School in 1928, he rejoined Admiral Field, Commander-in-Chief Mediterranean, as Chief of Staff, in the rank of Commodore First Class, until promoted to Rear-Admiral in 1929. When Admiral Field became First Sea Lord, Rear-Admiral im Thurn became Assistant Chief of Naval Staff and a Member of the Board of Admiralty. In 1933 he took over command of the First Cruiser Squadron in the Mediterranean Fleet, and was later promoted to Vice-Admiral. He brought his Squadron home for the naval review at Spithead to commemorate the Silver Jubilee of King George V in July 1935, and retired shortly afterwards. He returned to active service during the Second World War as a Commodore of Convoys, and later for duty at the Admiralty.

Vice-Admiral im Thurn was a lover of the countryside as well as the sea, and was a good shot and a keen fisherman. He was a man of the highest principles, who always put service before self, and who had an almost nostalgic love for the ships in which he served: two of his guest rooms at his house in Fareham were named *Ceres* and *Hood*. In those who served him closely he inspired loyalty, friendship and affection. He had deep religious conviction and, shortly before his retirement, adopted the Roman Catholic faith.

He joined The Institution as a Member in 1921. C. G. N.

CHARLES SIDNEY PARSONS

Charles Sidney Parsons, B.SC.(ENG.), who died on 1st April 1957, was born in London on the 28th December 1891. He gained a Drapers' Company scholarship and received his early education at Bancroft's School, Essex, and his engineering education at East London College, now Queen Mary College, where he obtained a B.Sc.(Eng.) degree. While at the college he carried out some research into mercury-arc rectifiers.

On leaving College in 1911 he first intended to become an examiner in the Patent Office but eventually entered the office of Dicker, Pollak and Derriman to study the Patent Agents' profession, in which he qualified in 1912. He then joined J. A. Law, Chartered Patent Agent, as technical assistant.

In September 1914 he volunteered for the Army, was commissioned in the Essex Regiment, and served in Gallipoli and Egypt, and subsequently in France with the Machine Gun Corps. He attained the rank of Major, but was wounded in March 1918 and discharged from the Army. The following year he returned to his profession as a Patent Agent, when he became Manager of the London branch of Forrester Ketley and Co., and in 1924 he became a partner in this firm. He commenced to practise on his own account in 1932.

He was the author of a book on patents, designs and trade marks, and he contributed various articles to the technical Press and a section on Patents, Designs and Trade Marks to *Kempe's Engineer's Year-Book*.

His great interests were golf, music and amateur theatricals, and he wrote a book on *Amateur Stage Management and Production*, and another, *A Guide to Theatrical Make-up*. He leaves a widow, and two sons.

Mr. Parsons joined The Institution as an Associate in 1920, and was elected a Companion in 1929, an Associate Member in 1946 and a Member in 1952. E. W. M.

GEORGE ALEXANDER VOWLES

George Alexander Vowles, O.B.E., died shortly before his 66th birthday, on the 13th May 1957. Born on the 30th May 1891, of a farming family in Somerset, he received his early education at Bath Forum School, Bath, his engineering education at the Technical School, Bath, and at Paddington Technical Institute, and his practical training with the Bath Corporation Electricity Department and the Metropolitan Electric Supply Co.

In 1920 he was appointed Combustion Engineer to the Newcastle-upon-Tyne Electric Supply Co. at the then new North Tees power station. This was the first station in this country to make a big advance in the use of higher steam pressure and temperature, and to install reheating. He transferred to the Worcester Corporation Electricity Department in 1923, where he was a maintenance engineer, and gained early experience with pulverized-fuel firing. The following year he was appointed to the City of Stoke-on-Trent Electricity Department as Power Station Superintendent, and in 1929 he became Personal Engineering Assistant to the Chief Engineer and Manager of the Hull Corporation Electricity Department. Here he took entire control of all generation work and helped with many managerial functions. In April 1934 he was promoted to Chief Engineer and Manager of the County Borough of Halifax

Electricity Department, and in April 1939 he went to Ipswich as Chief Engineer and Manager of the County Borough of Ipswich Electric Supply and Transport Departments. Here he acted as co-consultant for the new Cliff Quay power station. On nationalization of the supply industry in 1948, he was appointed Controller of the Yorkshire Generation Division of the British Electricity Authority, which position he held until just before his death.

In his early days 'G. A. V.' proved himself to be a first-class power station engineer, able to get the highest possible thermal efficiency, and to organize plant maintenance so that reliability was ensured and the highest economy obtained. His competence and his pleasant use of authority won the confidence and affection of the staff. His 'ship' was a happy one. He was appointed an O.B.E. in 1955.

His main hobby was game shooting, with golf as a close rival. He was blessed with a genial disposition, and while inclined to be intolerant of incompetence, his natural kindness made him a notable helper of 'lame dogs'. Friendship came naturally to him and once gained he was a truly staunch friend under all conditions. Many will mourn the passing of a true friend.

'G. A. V.' had a family of two sons—both engineers—and two daughters, and his family life was a particularly happy one.

He joined The Institution as a Graduate in 1928, and was elected an Associate in 1929, an Associate Member in 1936 and a Member in 1945. He served on the North Midland Centre Committee 1935–8 and on the Transmission Section Committee 1943–5.

J. N. W.

GEORGE FREDERICK PILDITCH

George Frederick Pilditch died on the 17th March 1957 at the age of 83 years. He received his technical training at Finsbury Technical College and his practical training with the London Electric Supply Corporation at their Deptford power station.

At the end of his training, he entered the service of the late Robert Hammond, a consulting engineer then engaged by many local authorities. After some experience in office work, he was sent to St. Helens, Lancashire, as Clerk of Works for Mr. Hammond, and supervised the electrical developments in that town. He then went to the County Borough of Ayr, in a similar capacity and to Rathmines, Dublin, where, on completion of his work for Mr. Hammond in 1900, he accepted the position of Chief Electrical Engineer to the Rathmines Urban District Council; he held this post until the Rathmines undertaking was succeeded by the Electricity Supply Board in 1931, when he retired.

George Pilditch was a most friendly and lovable character, unassuming as well as extremely helpful to his colleagues in The Institution. He was a member of the Milltown Golf Club, and an honorary life member of the Kenilworth Bowling Club. He is survived by his daughter.

He joined The Institution as a Student in 1893, and was elected an Associate in 1895, an Associate Member in 1899 and a Member in 1908. He served on the Dublin Local Section Committee for a number of years, was Vice-Chairman of that Committee in 1907–08 and Chairman in 1908–09. He was Honorary Treasurer of the Irish Centre (later Irish Branch) from 1934 to 1951, from which office he retired for health reasons.

J. D. F.

ERIC CONGER CROWLEY

Eric Conger Crowley died suddenly on the 15th March 1957 at the early age of 56 years. He was born at Wallington, Surrey, on the 21st April 1900, and was educated at St. Paul's School, Hammersmith, Kensington Coaching College and the City and Guilds College. His practical training with Underground Railways at Ealing was halted by service with the Middlesex Regiment from October 1918 to January 1919, and then resumed with Underground Railways at Golders Green. It was in 1920 that he commenced his electrical engineering education at the City and Guilds College, and in 1923 he was appointed Junior Assistant Engineer to the North Metropolitan Electric Power Supply Company. After three years with the Company he spent six years in Spain with the Barcelona Traction, Light and Power Company. Back in England in 1932 he was in private business until joining Sir Alexander Gibb and Partners in 1936. For them he supervised the erection of a power station in Fyzabad, United Provinces, India. From February 1937 to 1940 he assisted in the design and erection of electrical installations on the South Wales and West Cumberland Trading Estates and in Royal Ordnance factories. He continued ordnance factory work with Merz and McLellan from 1941 to 1942, when he joined the Ministry of Works. There he gave valuable assistance on a large programme of ordnance factories, hospitals, open-cast coal installations, etc.

Late in 1945 Mr. Crowley was sent to Germany as Senior Electrical and Mechanical Engineer, engaged on the dismantling and shipping to the United Kingdom of the plant and equipment of a large research establishment. Back in England he played a prominent part in the work of the Ministry on a number of large engineering installations. In 1950 there came a warning that his health would not stand up to the high pressure at which he always worked, but, characteristically, he continued to drive himself unsparingly. Further attacks ensued and in August 1956 he retired from the Ministry on medical grounds. However, within a short time he took up another appointment with a well-known firm of consulting engineers, with whom he worked until his sudden death. His colleagues, who knew him as a man of the highest integrity, sympathize with his widow and daughter in their tragic loss.

Mr. Crowley joined The Institution as a Student in 1923, and was elected a Graduate in 1927, an Associate Member in 1930 and a Member in 1947.

P. McK.

CORRESPONDENCE

ARS MARTIS COMES

From REGINALD G. PORTE, ASSOCIATE MEMBER

In the May issue of the *Journal* I was glad to read how the old 'Electricals' have now been absorbed into the Territorial Army.

I have also seen reference made to that grand old pioneer, the late Col. R. E. B. Crompton, and to the first detachment of 'Electricals' that went out to the South African War in 1900.* It might be of interest if I record that following the above detachment came A and B Companies (I was in B Company); they sailed for Cape Town in the S.S. *Bavarian* from Canada Dock, Liverpool, early in 1901, and under the command of Major J. Bain, C Company followed them out to South Africa later on.

Looking at an old survey map that I had with me in South Africa, I find that A and B Companies' contribution to the South African War in 1901–2 included duty at: Barberton (Natal); Vryheid (N.); Newcastle (N.); Pretoria (Transvaal); Johannesburg (T.) [Electrical Engineers' Headquarters]; Krugersdorp (T.); Elansfontein (T.); Middleberg (T.); Ermelo (T.); Standerton (T.); Heidelberg (T.); Vreeniging (T.) [Scene of the final peace conference, May 1902]; Heilbron (Orange River Colony); Kroonstad (O.R.C.); Bloemfontein (O.R.C.); Norvals Pont (Cape Colony); and De Aar (C.C.).

B Company were first home, after the end of hostilities; we entrained at Kazerne Station (Johannesburg) for Cape Town and sailed in the R.M.S. *Carisbrooke Castle* in July 1902. As we steamed up Southampton Water in the sunshine during Cowes week, England looked—beautiful!

* Incorrectly stated as 1899 on p. 108 of the February issue.—*Editor.*

MONOGRAPHS AND PAPERS
published individually this month

Synopses of monographs and papers published individually before the next issue of the Journal are given below, and, unless otherwise stated, their dates of publication are this month. Reprints of all papers are available about two months after publication in the Proceedings. The prices shown below are post free. When ordering please quote serial number of paper or monograph. Books of 8 vouchers may be obtained from the Secretary, price 10s. each.

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MONOGRAPHS

Coefficients for 'Decomposition' of Functions into Laguerre-Function Series *Monograph* 252 R

J. W. HEAD, M.A., *and* GWYNNETH M. OULTON, B.SC.

Given a function of time which behaves arbitrarily up to a certain time and is thereafter negligible, a satisfactory 10-term Laguerre-series approximation to the function can in general be written down in terms of the values of the function (obtained by graphical interpolation if necessary) at times proportional to the 10 zeros of the Laguerre function of order 10. The way in which the approximation fails when the procedure is deliberately applied to an unsuitable function is considered.

Transient Heating of Buried Cables *Monograph* 253 S

J. C. JAEGER *and* G. NEWSTEAD, M.E.E.

The paper develops exact methods of computing the thermal performance of buried cables, based on a solution of the relevant differential equations given by Jaeger in 1956.

The approach differs from that of other workers, who have used approximate methods of calculation. It is shown that the integrals occurring in the exact solution only require a small amount of computation, and if there is very great demand for this information, it could easily be codified by one of the national computing organizations.

The results obtained by the exact method are compared with those of other workers, particularly Whitehead and Hutchings (1938), and it is shown that, although their methods are generally satisfactory, they can lead to large discrepancies in particular cases; especially for small heating times. Calculations are made for a particular cable to show the application of the method.

PAPERS

Broad-Band Slot-Coupled Microstrip Directional Couplers *Paper* 2402 R: *Part B*

J. M. C. DUKES, M.A.

The paper describes a new design technique for directional couplers in a printed strip-above-ground microwave transmission system (microstrip). The two transmission lines are mounted back to back and coupled through slots in the common ground plane. The coupling factors of isolated slots of different shape are calculated and are found to be in good agreement with measured results. A specific design of 3 dB coupler is described in which the coupling mechanism consists of 100 printed transverse slots graded in length. By grading the phase velocity in one of the two lines at the same time a power split equal within 1 dB over the band 2 800–4 300 Mc/s is achieved.

The Application of Printed-Circuit Techniques to the Design of Microwave Components *Paper* 2401 R: *Part B*

J. M. C. DUKES, M.A.

A brief résumé is given of the basic theory of strip transmission lines, including unwanted effects such as spurious mode transmission and radiation. A variety of materials and different printed-circuit techniques have been tried and the relative merits of each are discussed. A technique of measurement is described and details are given of two pieces of specially developed measuring equipment in microstrip, namely an adjustable short-circuit and a wide-band precision attenuator. A number of new broad-band components covering the range 2 500–4 200 Mc/s are described; they include a reverse-phase hybrid-ring circuit, a back-to-back slot-coupled 3 dB directional coupler, and a new type of low-pass filter.

The Digital Computer Applied to the Design of Large Power Transformers *Paper* 2404 S: *Part A*

W. A. SHARPLEY *and* J. V. OLDFIELD, B.SC.(ENG.)

The paper describes an extensive investigation into the design of transformers with the aid of a high-speed digital computer. A general programme has been developed covering a range of transformers from 30 to 210 MVA; it has been tested for a wide range of designs within these limits. The subdivision of the process of design and its translation into a form suitable for a digital computer is described. Basic details of particular sub-routines are given to illustrate the problems of logic and arithmetic encountered. The techniques needed to control the design process within the computer are discussed, with special reference to the organization of data. A detailed description and derivation are given of the method used to obtain convergence to specified design characteristics without intervention by a designer. The results of several investigations concerned with the effect of changes to certain design parameters are included. These investigations would have been impracticable by hand.

SOME RECENT BOOKS

BERNARD ADKINS

THE GENERAL THEORY OF ELECTRICAL MACHINES

CHAPMAN AND HALL. 245 PP. £2 5S.

Most physical knowledge expands from some fundamental concept, only to grow diffuse and disjointed until a new genius restates a deeper, more comprehensive and (initially) all-embracing concept. Then the expansion begins again.

This kind of progress has certainly marked the history of electromagnetic machines, which are among the oldest electrotechnical devices known. Initiated by Faraday's great work, machines originally invented by an intuitive process have grown up with individual technologies—almost with unrelated languages.

The particular genius of the electromagnetic machine, who has been largely responsible for a high degree of unification as a result of a new concept, is Gabriel Kron. But Kron's tensor analysis is, for many, rather too abstract, and the transition from the old familiar technologies too abrupt. Fortunately an intermediate approach exists in the two-reaction method associated with the classic work of R. H. Park, using Blondel's original idea. The modern development of this approach is ably expounded in the present book. It is relatively easy to understand and needs only a grasp of general circuit theory.

What, basically, is an electromagnetic machine? It comprises two ferromagnetic structures capable of relative motion (usually, but not always, rotary) and carrying windings. There are no primary differences at all between the several 'types', which are only variants of the same basic structure. Such differences as there are result from the arrangement of the windings and the kind of electrical supply to which each is connected. Because magnetic poles occur in pairs, the two-pole machine is the unit; and, because the ferromagnetic structures are highly permeable, the region of chief magnetic interest lies in the gap between these structures.

It is in these terms that this book is written. Simplifications inseparable from a linear-circuit theory need to be made, but the result is both useful and satisfying. In brief, any machine behaves in a manner expressible in a few fairly simple equations relating to direct- and quadrature-axis quantities. The equations may apply directly to specific windings, or may apply only to equivalents of those windings and may need transformation to obtain actual winding currents and voltages. The expressions serve for all types of machine and to any condition—steady-state or transient. There is no doubt that this approach will gain rapid acceptance in more advanced analyses of machine behaviour. Its attractions are too strong to resist, and the unification is a logical step long overdue.

But the advantages are not gained without bloodshed. Secondary effects such as commutation and saturation are ignored, although often very important in any experimental approach. Experiment and theory line up only by inspired 'fiddling'. Again, the theoretical treatment does, at first, seem so remote, so arid. A proper understanding of a book on this level is scarcely possible without considerable practical experience with machines and their iron, copper, toil and sweat.

There is little opportunity here for adverse criticism, except in very minor matters of personal preference. The book achieves what it sets out to do, and one can only regret that the author did not extend his scope to outline the relation of the actual machine to the parameters that represent it. The book is substantially the first of its kind with the 'new look', and it will probably (and deservedly) be acknowledged as the standard text for years.

H. GÖNNINGEN

DER PAPIER-KONDENSATOR

SCHLITZ: GÖNNINGEN. 350 PP. £4 13S.

This book satisfies a long-felt need for a comprehensive textbook assembling the widely scattered literature on the impregnated paper capacitor. The information is presented in a highly classified form, separate chapters being devoted to basic properties, construction, design calculations, production, testing and applications. A final chapter gives worked-out examples of the design of several widely different types of capacitor, using the information contained in the previous chapters. Every conceivable aspect of paper capacitors is treated in detail, but from a severely practical point of view. For the theoretical background the reader is referred to the original papers—the bibliography containing 260 items.

Although the book was revised in 1956 and the bibliography contains quite recent papers, the developments of the last few years have perhaps been treated too cautiously. For instance, the metallized paper capacitor is mentioned rather than described, and the author's experience with chlorinated diphenyl impregnants has evidently been limited.

Another fault of the book is excessive duplication, forced on the author by his rigorously maintained classification into the chapters mentioned. For example, bitumen and synthetic resins for sealing capacitor cans are mentioned in the first chapter, in the second chapter they are described as part of the construction of capacitors, in the fourth chapter on manufacture the reader is told how to seal a capacitor by means of these compounds, and in the fifth chapter tests for their suitability are given. Such repetition makes reading difficult, and the book might have been shorter and cheaper if a different arrangement had been adopted.

The inclusion of many data from German standard specifications will no doubt be of value to the German readers. There is a very large number of illustrations. While the many graphs and data sheets are welcome, it seems unnecessary to include seven separate photographs of winding machines and several of commercial electrical instruments.

Despite these faults, the book provides the non-specialist with a good introduction to the subject, and the expert will find many useful hints as well as a mass of highly classified data.

INDUCTION AND DIELECTRIC HEATING

BRITISH ELECTRICAL DEVELOPMENT ASSOCIATION. 206 PP. 8S. 6D.

This book is No. 6 of a series on 'Electricity and Productivity' produced by the British Electrical Development Association to encourage the increased use of electricity for industrial processes. It is not surprising therefore that the advantages to be expected from high-frequency heating are reiterated with steady persistence.

The compiler has collected technical data from the makers and users of an extremely comprehensive range of h.f. heat-treatment installations and has obviously pursued his task with thoroughness and vigour. Almost all of the dozens of installations described are machines in actual use in industry, so that they might truthfully be described as 'attractive applications'. Unfortunately there is little to show which examples have been widely adopted, and which are perhaps isolated applications that proved worth while only in a particular set of circumstances. It is common experience in the h.f. heating industry that technical suitability goes but a short way towards making h.f. heating attractive and worth while. Other features such as production rates, rejects, acceptable tolerances, available labour force, etc., are often the ones that swing the balance for or against the adoption of h.f. techniques. It would not be reasonable to expect this book to examine each case in detail, but by omitting direct mention of the limits they impose, an unduly rosy picture of the role of h.f. heating is presented.

The very width of field covered is, however, a virtue of the book, for any process under consideration which has a close parallel in the book has a prima facie case for closer study: any which finds no family likeness among those described can probably be ignored in the present state of the art.

We must regret that the text was not given closer editing and proof-reading. It contains errors and inconsistencies of fact, of deduction, and of grammar. 'Early in the nineteenth century', we are told on p. 2, 'the phenomenon of induction heating was applied to the experimental melting of metals'. On p. 148 we read . . . 'it can cause skin burning, should live *or other* [reviewer's italics] exposed metal parts be touched'.

Frequency and power ranges for the various types of generators are quoted here and there, but the figures never quite agree. On p. 31 penetration depth is stated to be inversely proportional to frequency f, although the formula two lines earlier shows it correctly as inversely proportional to $\sqrt{f}$.

We are irritated by 'is' for 'are', 'and' for 'by', etc., and surely it is not necessary to tell us in almost the same words that 'large generator equipment is not required but the total heat treatment time is prolonged' twice in eight lines on p. 76?

A useful book written from a fresh viewpoint and including 154 excellent photographs, but it does need critical correction.

TECHNICAL PUBLICATIONS

H.M.S.O.

Freer Trade in Europe. 2s.

The Information Division of the Treasury and the Central Office of Information have recently issued a readable and useful booklet setting out the background of, and the facts about, the proposed Free Trade Area in Europe. This is printed in two colours and clearly illustrated with maps and diagrams. It includes an account of the two proposals for the European Economic Community and the Free Trade Area; a summary of Britain's present position; some questions and answers on salient points; and an informative section entitled 'Facts about Western Europe', which includes tables of population, production, imports and exports, trade restrictions, wages, etc., in European countries.

UNESCO

The International Geophysical Year. By Werner Buedeler. 3s.

A recently published Unesco booklet about the International Geophysical Year, which began on the 1st July, is available from Her Majesty's Stationery Office. It is addressed primarily to the layman and forms a readable account of the background to the I.G.Y. and the work that is to be carried out in the eighteen months' programme.

In his Preface to the booklet, the Director-General of Unesco writes:

Scientists of more than fifty nations and with widely differing training and skills are joining together for a united undertaking. Never before, except for war, have so many of them been mobilized for a common cause. The driving force in this case is for a better knowledge of our planet, the earth. Through the International Geophysical Year, described in this volume, there will be exploration of the atmosphere and beyond. Balloons will be topped by rockets and high altitude projectors which, in turn, will be followed by satellites believed by many to be the prelude to space travel.

The booklet includes accounts of solar effects on the earth, cosmic radiation, geophysics, the exploration of the atmosphere, the exosphere, aurorae, the ionosphere, the satellite programme, and Antarctica.

WORLD POWER CONFERENCE

Annual Report 1956

The Annual Report of the World Power Conference for 1956, which has recently been issued, includes a note on last year's meeting of the International Executive Council in Vienna, and a short report of the Fifth World Power Conference held there. A report of the International Commission on Large Dams and some information about future Sectional Meetings are also given; in particular, an appendix gives the final text of the technical programme for the Canadian Sectional Meeting in 1958. The report is obtainable from the Central Office of the World Power Conference, 201–2 Grand Buildings, Trafalgar Square, London, W.C.2.

CENTRAL ELECTRICITY AUTHORITY

The 275 kV System of the Central Electricity Authority in the United Kingdom. By F. J. Lane.

A booklet has recently been issued by the Central Electricity Authority which gives a general technical description of the 275 kV transmission system for Britain. This is based on a paper by Mr. F. J. Lane presented before the American Power Conference at Chicago in March 1957. It begins with an introduction to the 275 kV system, and two sketch maps illustrate the progress to December 1956 and the proposed development by 1960. Overhead lines, transformers, sub-stations, circuit-breakers and other equipment are described. The booklet includes eight photographs of 275 kV plant.

LIBRARY ACCESSIONS

**Denotes that the publication is also in the Lending Library. The publications cannot be bought through The Institution; the publishers and the prices are given only for the convenience of members.*

HÖLZLER, E., and HOLZWARTH, H. 621.396.619

Theorie und Technik der Pulsmodulation

Berlin, Springer, 1957. pp. xiv, 505. 24 × 17 cm. £4 15s.

Deals with amplitude, frequency, phase and pulse modulation and combinations such as pulse phase, and the generation of rectangular, sawtooth and other waveforms. Some circuit diagrams are given but the work is theoretical and mathematical. This book will be reviewed in a future issue.

JONES, E. B. 681.2

Instrument Technology. Vol. III Telemetering and Automatic Control*

London, Butterworths Scientific Publications, 1957. pp. x, 198. 28 × 15 cm. £2.

A practical work in which the mathematics has been kept as simple as possible. The section on telemetering covers pneumatic and electrical systems. The theory of automatic control is discussed; then the principles of controllers of varying complexity are described. Volume I of this series covered measurement of pressure, level, flow and temperature, and Volume II dealt with instruments for analysis.

JONES, F. L. 621.3.066.6

The Physics of Electrical Contacts*

Oxford, Clarendon Press, 1957. pp. x, 219. 22 × 14 cm. 35s.

Gives an account of, and elucidates, the fundamental physical processes involved in the operation of contacts. Describes recent investigations into the micro-phenomena of contact operation including the study of the microscopic molten-metal bridge. The properties of thin films and semi-conductors are considered, and the behaviour of metals at high temperatures is included in the range of electron and ionization physics covered by this book.

KELLER, P. R. 621.396.029.6

V.H.F. Radio Manual. Theory, practice and operation of commercial and amateur V.H.F. two-way radio systems, F.M. broadcasting transmitters and receivers, and television tuners*

London, Newnes, 1957. pp. vii, 216. 22 × 14 cm. 30s.

Covers the principles involved in the design of systems operating in the 30–450 Mc/s range, giving details of the circuits used for transmitters and receivers.

KEMP, P. 512.9

The j Operator for Electrical Engineers*

London, Macmillan, 1957. pp. 135. 22 × 14 cm. 21s.

A straightforward explanation of the j operator and its usefulness in solving problems in electrical circuits.

KOCH, W. 621.316.9

Erdungen in Wechselstrom anlagen über 1 kV. Berechnung und Ansführung. (Earths for A.C. Systems above 1 kV: their Design and Installation). 2nd ed.*

Berlin, Springer, 1955. pp. vi, 186. 24 × 15 cm. £1 13s. 4d.

Discusses the earth as a conductor of electric current and conductivity for varying soil conditions. Considers earths, earthing installation, including difficult conditions, neutral-point earthing and testing.

KÜCHLER, R. 621.314.2

Die Transformatoren. Grundlagen für ihne Berechnung und Konstruktion (Transformers. Fundamentals of their Design and Construction)

Berlin, Springer, 1956. pp. xi, 321. 23 × 15 cm. £2 16s. 5d.

Discusses the design of transformers in the light of developments over the last ten years. Of particular interest are the chapters on transformer noise and on cooling. The latter briefly discusses dry-type transformers.

KUHN, W. E (Editor) 621.365

Arcs in Inert Atmospheres and Vacuum*

London, Chapman and Hall, 1956. pp. viii, 188. 28 × 21 cm. £3.

Papers presented at a symposium held by the Electrochemical Society in San Francisco, 1956, and dealing with arc melting furnaces.

LECORGUILLIER, J. 621.314.6

Les Redresseurs de Courant dans l'Industrie (Rectifiers in Industry) Paris, Eyrolles, 1956. pp. 273. 24 × 16 cm. £2 18s.

Deals with the use of rectifiers in power circuits. Discusses circuits, smoothing and applications. Thyrations and ignitrons, copper and selenium metal rectifiers and germanium diodes are described.

LITTLER, D. J., and RAFFLE, J. F. 621.039

An Introduction to Reactor Physics. 2nd ed.

London, Pergamon, 1957. pp. x, 208. 22 × 14 cm. 30s.

This book explains the basic physics of the subject so that the principles involved in the construction of reactors can be understood.

MARKUS, J., and ZELUFF, V. 621.385

Handbook of Industrial Electronic Control Circuits*

London, McGraw-Hill, 1956. pp. xiv, 352. 28 × 22 cm. £3 6s.

'Handbook of industrial electronic circuits' contained circuits in use before 1948. This volume deals with circuits published in the period 1948–55. They include amplifiers, measuring, counting, multivibrator and photo-electric, transistor and many other groups of circuits, giving diagrams and values of components. They are all covered by a detailed index.

MARTIN, T. L. 537

Physical Basis for Electrical Engineering

Englewood Cliffs, N.J., Prentice-Hall, 1957. pp. xii, 410.

22 × 15 cm. £3 7s. 6d.

An explanation for engineers of modern physical theories. It covers electrostatic and electromagnetic fields in vacuum, atomic and nuclear structures, the structure and behaviour of metals and of semi-conductors, vacuum and gaseous tubes, insulators and capacitors, and the magnetic properties of matter.

MICHELS, W. C. 621.317

Electrical Measurements and their Applications*

London, Macmillan, 1957. pp. viii, 331. 24 × 16 cm. 30s.

This book is a successor to the author's 'advanced electrical measurements' published originally in 1932. The first part of it describes instruments and methods for measuring electrical quantities, including measurements at high frequencies. The remaining third of the book deals in a necessarily condensed way with measurements of magnetic and of non-electrical quantities, and details of instrument design have, in the main, been omitted. Bibliographical references are given.

MIDDLEBROOK, R. D. 621.314.7

An Introduction to Junction Transistor Theory*

London, Chapman and Hall, 1957. pp. xxiv, 296. 24 × 15 cm. £3 8s.

An introductory review of semi-conductor physics is followed by a description of the behaviour and characteristics of the p-n junction

and the p-n-p transistor. Equivalent circuits and applications are then described. Bibliographical references to further reading are given at the end of each chapter. This book will be reviewed in a future issue.

MILNES, A. G. 621.318.42

Transductors and Magnetic Amplifiers*

London, Macmillan, 1957. pp. ix, 286. 26 × 17 cm. £3 3s.

Single and 3-phase transductor circuits are discussed for a variety of load and operating conditions. Design methods are explained and applications of magnetic amplifiers described. Magnetic modulator devices, transductors with re-set voltage control and transistor controlled magnetic amplifiers are also discussed.

MOULON, J.-M. 621.314.7

Les Transistrons dans les Amplificateurs (Transistors in Amplifiers)

Paris, Gauthier-Villars, 1956. pp. 316. 24 × 16 cm. £2 10s.

Deals with the use of transistors for amplifiers of various types, including h.f., broad-band and d.c. amplifiers.

PHILLIPS, L. W. 51

Elementary Mathematics. 2nd ed.

London, Macdonald, 1957. pp. x, 361. 22 × 14 cm. 12s. 6d.

Covers elementary arithmetic, mensuration, algebra, graphs, geometry and trigonometry.

POUND, J. 621.365.5

Practical R.F. Heating for the Wood Industry*

London, Heywood, 1957. pp. viii, 198. 22 × 14 cm. 30s.

This is a simple explanation for the woodworker of how to use r.f. heating in the manufacture of plywoods and furniture.

SAMPSON, H. (Editor) 625.1

World Railways 1956–57. A World-wide Survey of Railway Operation and Equipment. 4th ed.

London, Sampson Low's 'World Railways,' 1956. pp. 502. 32 × 20 cm. £4 4s.

SCHRÖTER, F. (Editor) 621.397

Fernsehtechnik. Erster Teil. Grundlagen des elektronischen Fernsehens (Television Technique. Part One. Fundamentals of Electronic Television)*

Berlin, Springer, 1956. pp. xiii, 772. 25 × 17 cm. £7 11s. 3d.

A detailed study of television at its present stage of development. Beginning with an outline of the historical development, the book includes sections on vision and colorimetry, image analysis and scanning, and discusses the physics of the subject. Part 2 will cover techniques. This book was reviewed in the April issue.

STARR, A. T. 517

Mathematics*

London, Pitman, 1957. pp. ix, 547. 22 × 14 cm. £2 5s.

Covers the syllabus of Mathematics, Parts 1 and 2 for the engineering degree of London University and the Higher National Certificate. Contains worked examples in physics and electrical engineering. There is a chapter on the operational calculus.

SWIGGETT, R. L. 621.3.049

Introduction to Printed Circuits*

London, Chapman and Hall, 1956. pp. vii, 101. 22 × 14 cm. 21s.

A simple practical account of the various types of printed circuit now available and of suitable components for use with them.

WOODBURY, D. O. 92 (Wes)

A Measure for Greatness. A short biography of Edward Weston

London, 1949. pp. vii, 230. 23 × 15 cm. 30s.

A record of the inventiveness and struggles of Edward Weston, first to improve electroplating, then to develop the dynamo and later the arc lamp, and subsequently to produce instruments for measuring electrical quantities. Much of the story concerns his business ventures and the patent litigation so common in America at the time.

OTHER PUBLICATIONS

ALUMINIUM DEVELOPMENT ASSOCIATION

Aluminium in Electrical Engineering

London, Aluminium Development Association, 1957. pp. 72. 28 × 21 cm. 4s. 6d.

B.B.C. ENGINEERING DIVISION

An Improved 'Roving Eye' by T. Worswick and G. W. H. Larkby

London, B.B.C. Engineering Division, Monograph No. 12, 1957. pp. 19. 28 × 22 cm. 5s.

BETTRIDGE, B. R. A.

Transistors. Circuits and Servicing

London, Trader Publishing Co., 1957. pp. 23. 22 × 15 cm. 2s. 6d.

BRITISH ELECTRICITY SUPPLY DELEGATION

Report on a Visit to the U.S.S.R. 16th April–14th May, 1956

London, British Electricity Supply Delegation, 1957. pp. x, 92. 25 × 20 cm.

INTERNATIONAL ELECTROTECHNICAL COMMISSION

Recommendations for Electrical Installations in Ships

Geneva, International Electrotechnical Commission, 1957.

Publication No. 92. pp. 175. 29 × 21 cm. £1 10s.

MINISTRY OF EDUCATION

The Supply and Training of Teachers for Technical Colleges. Report of a Special Committee appointed by the Minister of Education in September, 1956

London, H.M.S.O., 1957. pp. xiv, 68. 24 × 15 cm. 4s.

MINISTRY OF LABOUR AND NATIONAL SERVICE

Factory Department

Electrical Accidents and Their Causes 1955

London, H.M.S.O., 1957. pp. 76. 24 × 15 cm. 4s.

UNITED NATIONS ECONOMIC COMMISSION FOR EUROPE

The Electric Power Situation in Europe in 1955

Geneva, U.N., 1957. pp. iv, 61. 28 × 21 cm. 3s.

Rural Electrification Vol. II

Geneva, U.N., 1957. pp. ii, 126. 28 × 21 cm. 7s.

Forthcoming Events

September 1957

5–9 *Thursday–Monday* Supply Section Visit to Belgium

18–22 *Wednesday–Sunday* Radio and Telecommunication Section Visit to the Netherlands

October 1957

3 *Thursday* Opening Meeting of the 1957–58 Session (Presidential Address by Mr. T. E. Goldup, C.B.E.)

Elections and Transfers

The following elections and transfers approved by the Council are effective from the 27th June 1957.

ELECTIONS

Graduates

ANDERSON, James, B.SC.
BALL, Reginald Maurice
BEAN, Robert Frederick
BECK, Ian Henry
BOWDEN, William Roy
BROWN, John Valentine
CHAPMAN, Reginald Walter
CLOTHIER, Edward Thomas
COLLINS, Terence Allan
COOKE, David John, B.E.
DAWSON-TAYLOR, Sub.-Lt. David, B.A., R.N.
EISNER, Mark, B.E.
FOX, Derek George
GRAINGER, Albert
GRONOW, Sydney Reginald
HAMMETT, Ernest Henry
HARDY, Jack Edward
HOLDEN, Stanley
HOLLEBON, Ronald David
HONESS, John Stuart
HOSKIN, Leslie
HURST, Frank
HUTCHINSON, Stanley
JACKSON, George Graham
LAWSON, John Andrew
LIDDELL, William Heron
MCCAUGHAN, Ronald
MANDT, Sigmund Tore
MISRAHI, Jacob, B.SC.(ENG.)
OWEN, Peter Lumsden Tudor, B.A.
PECKITT, Francis Trevor
PETTIFER, John Kenyon, B.A.
RICHARDS, William Cyril Desmond
RIDLER, Raymond William
ROGERS, Warwick Owen
SLY, Maurice Edward
SMITH, Colin Francis Greening
SMITH, Thomas William
STUDD, Peter John, B.A.
THOMAS, Derek Alfred
WARDALE, Sub.-Lt. Anthony Thomas, B.A., R.N.
WARWICK, Eric
WATERFALL, Kenneth Lionel, B.E.
WATERS, George Thomas, B.E.
WATERTON, James Charles, B.A.
WATSON, David, B.SC.
WILTSHIRE, Dennis Frank
WONG, David Gilbert, B.SC., B.E.

Students

APLIN, Christopher Francis
ASHBY, Gerald Terence, B.SC.
BAILEY, Richard William
BRACKEN, Neville Guy
BRADLEY, David
BROWN, Charles Liversidge
BRYAN-BROWN, David
BUCKLEY, Philip Waring
CASSERLEY, David John
CHARLES, Ivo John
CLAPPISON, Paul Alexander
COOK, Brian Peter
DAVIES, Peter Graham
DODSON, John
DUPPA-MILLER, Francis Peter
EDDY, David Charles Ancell, B.SC.
EWER, George Anthony
FROW, Roger
GATISS, John William
GRE:N, David Alwyn
HAMMOND, James William
HANLON, John Edward Jeremy
HANNAFORD, David Arthur
HULL, Peter Reynold
ISMAIL, Nizam
JOHNSON, William David
LANGE, Graham Warren
LEWIS, James Beverley
LISBONA, Raymond Edmond
MADDEN, Lyle Stanley
MIAO, Chi
MILLER, Vincent Eugene, B.SC.
MITCHELL, Terence, B.SC.
NIELSON, Adrian William
PILLING, Oliver Jackson
PROSSER, Jeffrey William
QUIRK, John Hugh Gibbons
RABRA, Jagan Nath
ROGERS, William James Stuart
SAXENA, Mahesh Kumar, B.SC.
SELWOOD, John William
SHIRTLIFF, Peter John
SIMPKIN, Laurence Edward
SKITT, Robert Frank
SLADEN, Douglas Kevin
SUMANATILAKE, Piyadigamage Saranapala
SUTCLIFFE, Derek Graham Rawnsley
TILLEY, Brian John
VILLAVARAYAN, Sebastiampillai Cecil, B.SC.
VON KROGH, Karl
WEAVING, Derek John
WELLINGS, Donald Clive
WICKRAMASINGHE, Jayasinghe Bharatha Augustus
WILD, John Kenneth

TRANSFERS

Student to Graduate

BACON, Leonard Francis
BLAKE, David John, B.SC.
BOOL, Christopher John, B.SC.(ENG.)
CHAMPION, Michael John
DIAMOND, Robert Lindsay
FIELDING, Francis Langford
FORFOD, Thorleif Ragnar, B.SC.
LOONG, Sow Toong
OTTER, Alan John, B.SC.
SEELEY, John Scott, B.SC.(ENG.), PH.D.
SHARMA, Kailash Prasad, M.SC.
SIMON, Frederick Armenak
SIMPSON, Douglas John, B.SC.(ENG.)
SMITH, John Edmund, B.SC.(ENG.)
WHITWORTH, Michael Conroy, B.SC.

The following elections and transfers approved by the Council are effective from the 1st July 1957.

ELECTIONS

Member

BURT, Brian Morton, B.SC.TECH.

Associate Members

BARNES, Geoffrey,
BIRCH, Roy Gerald, B.SC.
BLOWER, Donald William, B.SC.
BURROWS, John Geoffrey
CLARKE, Major Albert John, R. SIGNALS
DALGLEISH, Donald Ian, B.SC.(ENG.)
ELIOT, Cmdr. Christian John Marriott, R.N.
GIBSON, Senan William, B.E.
HANEBECK, Emil Friedrich Gottlieb, DIPL.ING.
JONES, Ronald Royston
RIDLEY, John,Collingwood
SHORE, Leslie
SMOLINSKI, Professor Adam Karol, DR.ING.
SQUIRE, Leonard Ernest
STRATTON, James Douglas
TREHARNE, Ross Fredrind, B.SC., B.E.
YOUNG, Kenneth John

Associates

CHAMBERLAIN, Herbert Philip George
COURT, Major John Charles, R.E.
GROSE, Basil Hubert
HAYNES, John
JEFFRIES, Walter Charles
REECE, Percy Cairns

TRANSFERS

Associate Member to Member

ANDERSON, Ronald Thomas Watson
BROOKE, Cmdr. Ralph Crichton Rupert, R.N.V.R.
BURT, Harry Kyle Peddie, B.SC.(ENG.)
CARRASCO, Joseph, B.SC., B.SC.(ENG.)
DARK, Cyril Montague
GLOVER, William Frank, B.ENG.
HEWETT, George Nele
HOLLIDAY, Bertram John
KELSEY, Thomas Hubert, M.A.
LAWRENCE, William Minett
MALAKSEERAT, Hassan
RAZDAN, Suraj Narayan, B.SC.(ENG.)
REDFERN, George, M.A.
SIKLOS, Theodore, Dr.Ing.
SIMPSON, Charles Brian, B.SC.TECH.
WATT, James Leslie, M.C.

Associate to Associate Member

STUBBS, Thomas Maurice Harold

Graduate to Associate Member

ALLEN, William Duncan, B.SC.(ENG.)
BAILEY, William
BANKS, Kenneth Maurice
BARNFIELD, Leonard Gerald
BEVAN, Raymond Albert, B.SC.
BICKNELL, Gordon Alexander
BIRCH, John
BURLEY, James Alan
CARRODUS, Frank
CLARK, Edwin George
COOK, John Louis
COSGRAVE, Stanford Thomas
COTTRELL, Arthur Raymond
DRURY, Robert David, B.SC.
EASTGATE, Clive
ECKERSLEY, Geoffrey Buck, B.SC.(ENG.)
EDWARDS, Kenneth
FOSS, Lt. Arthur Thomas William, R.N.
FRENCH, Gordon Percival, B.SC.(ENG.)
GACKOWSKI, Roman, B.SC.(ENG.)
GALLEY, Cyril, B.SC.
GARNER, Kenneth Charles, B.SC.(ENG.)
GRIDLEY, John Henry, B.SC.(ENG.)
HALLIWELL, Gordon Gray, B.SC.TECH.
HARDIMAN, Thomas Patrick, B.E., B.SC.
HART, Dudley
HODGSON, Leslie
HOMPSTEAD, Leslie Robert
HUDSON, John Thackeray, B.E.
JACOBS, Derek Arthur, B.SC.(ENG.)
JAMESON, Kenneth
JORDAN, Bernard James
JOSS, James Ormond, B.SC.
KENNEDY, Richard
KETIPEARACHCHI, Lairis
KIRKBY, David Courtenay
LANGLEY, Henry James, B.SC.(ENG.)
LATTO, James
LEATHER, Russell Allan, B.SC.
LIPINSKI, Florian
LIVESLEY, John Ronald, B.ENG.
LOVE, Alexander Robert, B.E.
LYNCH, George Arthur
MACEWAN, James Duncan, B.SC.
MANN, Peter William
MARTIN, James Edgar
MUTTER, Robert Fleming, B.SC.
NISBET, Robert Alexander
OKELL, John Cyril, B.SC.(ENG.)
PATERSON, Andrew Wilson Brownhill, B.SC.
PODKOLINSKI, Andrej Kazimierz
RICHARDSON, Peter Ernest
ROGERS, Rodney Austin
SHEARD, Leslie
SHEARS, Philip Antony, B.A.
SKINNER, John
STANESBY, Arthur Owen, M.A.
STANKIEWICZ, Wojciech, B.SC.TECH.
STANTON, William Avery
STATTER, Charles John Crossman, B.SC., B.E.
STEPHENSON, Maurice
SUBRAHMANYAM, Dharmavadhani Krishnaiyer
TRAIL, Gordon James
UNWIN, George Henry
VICK, Peter Sidney
WALKER, Eric George
WALLACE, Edward, B.SC.
WARING, Leslie Phillip
WHITWORTH, Jack William Georges
WILKINS, Norman George
WILLARD, David Oswald
WILLCOCK, Frederick
WILLIS, Donald Wesley, M.A.
YOUNG, Benjamin Lauder
YOUNG, John Frederick

Student to Associate Member

PAGE, Robert Henry Albert

Student to Associate

LAMB, Bernard Samuel

ANNOUNCEMENTS TO MEMBERS

THE HOMES FUND

SUMMARY OF CONTRIBUTIONS RECEIVED TO 25TH JULY 1957

	No. of Contributors	£	s.	d.
£1 000 and over	6	6 000	0	0
£100 to <£1 000	30	6 586	3	0
£5 to <£100	834	8 879	12	1
£2 to <£5	2 010	5 499	14	11
Under £2	21 931	11 469	12	0
		£38 435	2	0

ELECTION OF SECTION COMMITTEES FOR THE YEAR 1957–58

MEASUREMENT AND CONTROL SECTION

The following were nominated for the vacancies which will occur on the Committee of the Measurement and Control Section on the 30th September next:

Chairman H. S. PETCH, B.SC.(ENG.)

Vice-Chairmen

J. K. WEBB, M.SC.(ENG.), B.SC.TECH. — PROFESSOR A. TUSTIN, M.SC.

Ordinary Members of Committee

E. W. CONNON, B.SC.(ENG.), M.ENG. — A. J. MADDOCK, D.SC.
C. G. GARTON — G. A. V. SOWTER, PH.D., B.SC.(ENG.)

No other nominations having been received, the constitution of the Committee for next session will be as follows:

Chairman H. S. PETCH, B.SC.(ENG.)

Vice-Chairmen

J. K. WEBB, M.SC.(ENG.), B.SC.TECH. — PROFESSOR A. TUSTIN, M.SC.

Past-Chairmen

D. TAYLOR, M.SC., PH.D. — W. BAMFORD, B.SC.

Ordinary Members of Committee

J. BELL, M.SC. — W. C. LISTER, B.SC.
E. W. CONNON, B.SC.(ENG.), M.ENG. — A. J. MADDOCK, D.SC.
D. EDMUNDSON, B.SC.(ENG.) — R. S. MEDLOCK, B.SC.
W. S. ELLIOTT, M.A. — G. A. V. SOWTER, PH.D., B.SC.(ENG.)
C. G. GARTON — R. H. TIZARD, B.A.
PROFESSOR K. A. HAYES, B.SC.(ENG.) — M. V. WILKES, M.A., PH.D., F.R.S.

Together with the following:

The President
A Representative of the Council
The Chairman of the Papers Committee
A Representative of each Local Measurement Group
A Representative of the National Physical Laboratory

RADIO AND TELECOMMUNICATION SECTION

The following were nominated for the vacancies which will occur on the Committee of the Radio and Telecommunication Section on the 30th September next:

Chairman (*a*) J. S. MCPETRIE, PH.D., D.SC.

Vice-Chairman (*a*) M. J. L. PULLING, O.B.E., M.A.

Ordinary Members of Committee (*three vacancies*)

(*a*) R. J. HALSEY, C.M.G., B.SC.(ENG.) — (*b*) J. B. SUPPER
(*a*) B. G. PRESSEY, M.SC.(ENG.), PH.D. — (*a*) W. E. WILLSHAW, M.B.E., M.SC.TECH.

(*a*) Nominated by the Section Committee.
(*b*) Nominated by Wing-Cmdr. C. D. Connerton, N. H. Elgood, H. B. Morton, R. I. Wells, and P. G. Whicher.

A ballot has been held and the result has been reported by the scrutineers appointed at the Section Meeting held on the 15th May 1957.

The constitution of the Committee for next session will, accordingly, be as follows:

Chairman J. S. MCPETRIE, PH.D., D.SC.

Vice-Chairmen

G. MILLINGTON, M.A., B.SC. — M. J. L. PULLING, O.B.E., M.A.

Past-Chairmen

H. STANESBY — R. C. G. WILLIAMS, PH.D., B.SC.(ENG.)

Ordinary Members of Committee

A. J. BIGGS, PH.D., B.SC. — B. G. PRESSEY, M.SC.(ENG.), PH.D.
W. J. BRAY, M.SC.(ENG.) — W. ROSS, M.A.
H. A. M. CLARK, B.SC.(ENG.) — T. B. D. TERRONI, B.SC.
C. W. EARP, B.A. — D. R. TURNER, M.ENG.
V. J. FRANCIS, B.SC. — F. WILLIAMS, B.SC.
R. J. HALSEY, C.M.G., B.SC.(ENG.) — W. E. WILLSHAW, M.B.E., M.SC.TECH.

Co-opted Member E. H. COOKE-YARBOROUGH

Together with the following:

The President
A Representative of the Council
The Chairman of the Papers Committee
A Representative of each Local Radio and Telecommunication Group
A representative of each of the three Fighting Services

SUPPLY SECTION

The following were nominated for the vacancies which will occur on the Committee of the Supply Section on the 30th September next:

Chairman (*a*) PROFESSOR M. G. SAY, PH.D., M.SC.

Vice-Chairmen

(*a*) J. E. L. ROBINSON, M.SC. — (*a*) D. P. SAYERS, B.SC.

Ordinary Members of Committee (*four vacancies*)

(*a*) C. H. FLURSCHEIM, B.A. — (*b*) C. T. W. SUTTON, M.SC.(ENG.)
(*a*) W. J. NICHOLLS, B.SC. — (*a*) A. L. WILLIAMS, PH.D., M.SC.
(*a*) J. E. PETERS, B.SC.TECH.

(*a*) Nominated by the Section Committee.
(*b*) Nominated by C. C. Barnes, S. Chaplin, W. H. L. Lythgoe, A. M. Morgan, and M. J. Smith.

A ballot has been held and the result has been reported by the scrutineers appointed at the Section Meeting held on the 22nd May 1957.

The Committee have co-opted Mr. G. S. Buckingham, B.SC.(ENG.), to fill the vacancy created by the election of Mr. J. E. L. Robinson, M.SC., as a Vice-Chairman before the completion of his term of office as an Ordinary Member of Committee.

The constitution of the Committee for next session will, accordingly, be as follows:

Chairman PROFESSOR M. G. SAY, PH.D., M.SC.

Vice-Chairmen

D. P. SAYERS, B.SC. — J. R. MORTLOCK, PH.D., B.SC.(ENG.)
J. E. L. ROBINSON, M.SC.

Past-Chairmen

P. J. RYLE, B.SC.(ENG.) — L. DRUCQUER

Ordinary Members of Committee

J. A. BROUGHALL, B.SC. — P. M. HOLLINGSWORTH, M.ENG.
F. H. S. BROWN, B.SC. — W. J. NICHOLLS, B.SC.
G. S. BUCKINGHAM, B.SC.(ENG.) — J. E. PETERS, B.SC.TECH.
O. J. CROMPTON, M.ENG. — E. P. G. THORNTON
C. H. FLURSCHEIM, B.A. — F. C. WALMSLEY
C. P. HOLDER, B.A. — A. L. WILLIAMS, PH.D., M.SC.

Together with the following:

The President
A Representative of the Council
The Chairman of the Papers Committee
A Representative of each Local Supply Group

UTILIZATION SECTION

The following were nominated for the vacancies which will occur on the Committee of the Utilization Section on the 30th September next:

Chairman J. VAUGHAN HARRIES

Vice-Chairman R. A. MARRYAT, B.SC.(ENG.)

Ordinary Members of Committee

W. J. GIBBS, D.SC.
LT.-COL. R. J. HARDING, T.D.
R. P. MCCULLOCH, B.ENG.
W. G. THOMPSON, PH.D., B.SC.

No other nominations having been received, the constitution of the Committee for next session will be as follows:

Chairman J. VAUGHAN HARRIES

Vice-Chairmen

O. W. HUMPHREYS, C.B.E., B.SC., F.INST.P.
R. A. MARRYAT, B.SC.(ENG.)

Past-Chairmen

H. J. GIBSON, B.SC.
D. B. HOGG, M.B.E., T.D.

Ordinary Members of Committee

B. ADKINS, M.A.
R. H. M. BARKHAM, B.SC.(ENG.)
H. H. C. BARTON, B.A.
J. M. FERGUSON, B.SC.(ENG.)
W. J. GIBBS, D.SC.
LT.-COL. R. J. HARDING, T.D.
T. E. HOUGHTON, M.ENG.
J. B. LANCASTER, B.SC.
R. P. MCCULLOCH, B.ENG.
P. MCKEARNEY, O.B.E.
H. G. TAYLOR, D.SC.(ENG.)
W. G. THOMPSON, PH.D., B.SC.

Together with the following:

The President
A Representative of the Council
The Chairman of the Papers Committee
A Representative of each Local Utilization Group
Representatives of the Admiralty, the Air Ministry, the Ministry of Labour and National Service (Factory Department), the Ministry of Works and the War Office

AWARD OF PREMIUMS

The Council have made the following award of premiums for papers read or accepted for publication during the 1956–57 Session:

GROUP A

The Institution Premium (value £50)

T. Ingledow, D.SC., R. M. Fairfield, B.SC.(ENG.), E. L. Davey, B.SC.(ENG.), K. S. Brazier, B.SC.(ENG.), and J. N. Gibson — 'British Columbia–Vancouver Island 138 kV Submarine Power Cable'

The Kelvin Premium (value £25)

H. B. Law, B.SC.TECH. — 'The Detectability of Fading Radiotelegraph Signals in Noise'

H. B. Law, B.SC.TECH. — 'The Signal/Noise Performance Rating of Receivers for Long-Distance Synchronous Radiotelegraph Systems using Frequency Modulation'

The John Hopkinson Premium (value £25)

E. T. Norris — 'Mechanical Strength of Power Transformers in Service'

GROUP B

Measurement and Control Section Premiums

The Silvanus Thompson Premium (value £20)

M. E. Haine, M.SC., and M. W. Jervis, M.SC.TECH. — 'The Ultimate Performance of the Single-Trace High-Speed Oscillograph'

M. E. Haine, M.SC., and M. W. Jervis, M.SC.TECH. — 'The Design and Performance of a New Experimental Single-Transient Oscillograph with Very High Writing Speed'

The Mather Premium (value £15)

L. Hartshorn, D.SC., and J. J. Denton, B.SC. — 'The Calibration of Inductance Standards at Radio Frequencies'

Premiums (value £5)

P. R. Howard, PH.D., B.SC.(ENG.) — 'Insulation Properties of Compressed Electronegative Gases'

P. R. Howard, PH.D., B.SC.(ENG.) — 'Processes Contributing to the Breakdown of Electronegative Gases in Uniform and Non-Uniform Electric Fields'

G. E. P. Box, B.E.M., B.SC., PH.D., and G. A. Coutie, M.A. — 'Application of Digital Computers in the Exploration of Functional Relationships'

E. C. Greanias, M.S., C. J. Hoppel, B.S., M. Kloomok, M.S., and J. S. Osborne, B.S. — 'The Design of a Logic for the Recognition of Printed Characters by Simulation"

Radio and Telecommunication Section Premiums

The Duddell Premium (value £20)

G. L. Grisdale, PH.D., J. G. Morris, B.SC., and D. S. Palmer, M.A. — 'Fading of Long-Distance Radio Signals and a Comparison of Space- and Polarization-Diversity Reception in the 6–18 Mc/s Range'

The Ambrose Fleming Premium (value £15)

Professor H. E. M. Barlow, PH.D., B.SC.(ENG.) — 'Hall Effect and its Counterpart, Radiation Pressure, in Microwave Power Measurement'

Premiums (value £5)

B. G. Pressey, M.SC.(ENG.), PH.D., and G. E. Ashwell, B.SC. — 'The Deviation of Low-Frequency Ground Waves at a Coast Line'

B. G. Pressey, M.SC.(ENG.), PH.D., G. E. Ashwell, B.SC., and C. S. Fowler — 'Change of Phase with Distance of a Low-Frequency Ground Wave Propagated Across a Coast-Line'

E. W. Hayes and H. Page, M.SC. — 'The B.B.C. Sound Broadcasting Service on Very-High Frequencies'

R. T. B. Wynn, C.B.E., M.A., and F. A. Peachey — 'The Remote and Automatic Control of Semi-Attended Broadcasting Transmitters'

A. G. Milnes, D.SC. — 'Transistor Circuits and Applications'

T. Somerville, B.SC., and C. L. S. Gilford, M.SC. — 'Acoustics of Large Orchestral Studios and Concert Halls'

J. B. Goodenough, PH.D. — 'The Influence of Chemistry on B/H Loop Shape, Coercivity and Flux-Reversal Time in Ferrites'

T. B. A. Senior, M.SC., PH.D. — 'Radio Propagation Over a Discontinuity in the Earth's Electrical Properties—I'

T. B. A. Senior, M.SC., PH.D. — 'Radio Propagation Over a Discontinuity in the Earth's Electrical Properties—II. Coastal Refraction'

E. D. Daniel, M.A., P. E. Axon, O.B.E., M.SC., PH.D., and W. T. Frost — 'A Survey of Factors Limiting the Performance of Magnetic Recording Systems'

J. Brown, M.A., PH.D., and J. O. Spector, PH.D. — 'The Radiating Properties of End-Fire Aerials'

W. F. Glover, B.ENG., and S. E. Buckley, B.SC. — 'Ferrites Applied to Carrier Frequency Equipment'

Supply Section Premiums

The Sebastian de Ferranti Premium (value £20)

No Award.

The John Snell Premium (value £15)

H. Goldenberg, M.SC. — 'The Calculation of Cyclic Rating Factors for Cables Laid Direct or in Ducts'

A Premium (value £5)

A. Morris Thomas, B.SC., and D. F. Oakeshott, B.SC. — 'Choice of Insulation and Surge Protection of Overhead Transmission Lines of 33 kV and Above'

Utilization Section Premiums

The Crompton Premium (value £20)

Professor F. C. Williams, O.B.E., D.SC., D.PHIL., F.R.S., E. R. Laithwaite, M.SC., and L. S. Piggott, M.SC. — 'Brushless Variable-Speed Induction Motors'

E. R. Laithwaite, M.SC., and P. J. Lawrenson, B.SC. — 'A Self-Oscillating Induction Motor for Shuttle Propulsion'

The Swan Premium (value £15)

T. E. Calverley, B.SC.(ENG.), and D. G. Taylor, B.SC.(ENG.) — 'Circuit Calculations for Rectifier Locomotives and Motor Coaches'

Premiums (value £5)

L. R. Blake, PH.D., B.SC.	'Conduction and Induction Pumps for Liquid Metals'
H. B. Calverley, B.SC.(ENG.), E. A. K. Jarvis, B.SC., and E. Williams, B.SC.(ENG.)	'Electrical Equipment for Rectifier Locomotives'

Non-Section Premiums

The Ayrton Premium (value £20)
No award.

The Llewellyn B. Atkinson Premium (value £15)
No award.

Premium (value £5)

Professor E. G. Cullwick, O.B.E., M.A., D.SC.	'Magnetic Energy and Electron Inertia in a Superconducting Sphere'

GROUP C

The Blumlein–Browne–Willans Premium (value £20)
No award.

The Fahie Premium (value £10)

J. W. Allnatt, B.SC.(ENG.), E. D. J. Jones and H. B. Law, B.SC.TECH.	'Frequency Diversity in the Reception of Selectively Fading Binary Frequency - Modulated Signals, with special reference to Long-Distance Radiotelegraphy'

The Frank Gill Premium (value £10)
No award.

The Heaviside Premium (value £10)

D. G. Lampard, M.SC., PH.D.	"A New Theorem in Electrostatics with Applications to Calculable Standards of Capacitance'

The Paris Exhibition (1881) Premium (value £10)
No award.

The Webber Premium (value £10)

D. C. Flack, B.SC.(ENG.), PH.D.	'Future Trends in Aircraft Electrical Systems'

Oversea Premiums

For Senior Members (value £10)

W. K. Clothier, M.E., and L. Medina, DIPL.ING.	'The Absolute Calibration of Voltage Transformers'
J. M. Magowan	'Voltage Performance of Series Capacitors in Transmission and Distribution Lines'

For Students and Graduates under 28 years of age (value £5)
No award.

Graduate and Student Premiums

Premiums (value £10)

Author	*Title*	*Section*
A. E. D. Heylen, B.SC.(ENG.)	'Electric Breakdown in Gases'	London
R. E. James, B.SC.(ENG.)	'Testing of High Voltage Power Transformers'	Rugby
R. S. Wignall, B.SC.	'Project Considerations for Diesel Electric Traction'	North Midland

The Henry Nimmo Premium (value £10)

J. G. Page, B.SC.	'33 kV System Development'	East Midland

Premiums (value £5)

J. A. Denham, B.SC.(ENG.)	'The Thermal Endurance of Insulating Materials'	North-Eastern
J. C. Earls, B.SC.(ENG.)	'Some Aspects of Analogue Computation'	North Scotland
C. F. Ferguson, B.SC.(ENG.)	'Modern Techniques in the Protection of Large Turbo-Alternators'	North Staffordshire
R. D. Langman, B.SC.(ENG.)	'Basic Analogue Computing applied to Control System Synthesis and Analysis'	North Staffordshire
J. W. S. Payne, B.SC.(ENG.)	'The Performance and Application of Magnetic Amplifiers'	Rugby
E. J. Stocks, B.SC.(ENG.)	'Television Film Recording'	London

Letters of Commendation

J. A. Barber, B.SC.	'Auto-Following Radar Systems'	London
R. F. Burbidge, B.SC.	'2/1 Pole-Changing Motors'	Bristol
P. F. Kennedy, B.SC.	'The Electrolytic Tank and its Application to Design Problems'	North-Eastern
R. Porter, B.SC.	'The Application of Contactors and High-Rupturing-Capacity Fuses to the Control of Motor Circuits'	Mersey and North Wales
P. L. M. Rockwell, B.SC.(ENG.) .	'Air Navigation'	London

APPOINTMENTS

WIRING REGULATIONS COMMITTEE

On the nomination of the Electric Lamp Industry Council, the Council have appointed Mr. W. J. Jones, M.SC.(ENG.), MEMBER, to serve on the above Committee.

On the nomination of the Associated Offices Technical Committee, the Council have appointed Mr. W. McDermott, B.SC., MEMBER, to serve on the above Committee.

SOUTH MIDLAND CENTRE

FORMATION OF RADIO AND MEASUREMENT GROUP

The Council have recently approved the establishment of a Radio and Measurement Group in the South Midland Centre in succession to the former Radio and Telecommunication Group.

ELECTRONIC COMPUTER EXHIBITION

An Electronic Computer Exhibition, sponsored by a joint committee of the Radio Communication and Electronic Engineering Association and the Office Appliance and Business Equipment Trades Association, will take place at Olympia from the 28th November to 4th December 1958. The exhibition will cover only electronic computers and allied equipment, and concurrently with it a technical symposium and a business computer symposium will be held. Further particulars may be obtained from Mrs. S. S. Elliott, 11 Dowgate Hill, London, E.C.4.

'INTERKAMA'

DÜSSELDORF: NOVEMBER 1957

Under the title 'Interkama' an International Congress and Exhibition of Measuring, Instrumentation and Automation will be held in Düsseldorf from the 2nd to 10th November 1957. The organizers of the Congress are Verein Deutscher Ingenieure, Verband Deutscher Elektrotechniker and Verein Deutscher Eisenhüttenleute. The Congress will consider general problems and the future scope of instrumentation and automation. Manufacturers will have an opportunity to lecture on newly-developed equipment. Further information may be obtained from Nordwestdeutsche, Ausstellungsgesellschaft m.b.H., Düsseldorf, Ehrenhof 4, Germany.

AMERICAN CONFERENCE ON ELECTRICAL INSULATION

The Annual Meeting of the American Conference on Electrical Insulation (under the auspices of the National Academy of Sciences' National Research Council) will again be held at Pocono Manor, Pennsylvania. This year the period of the Conference will be the 21st to 23rd October, and the final programme will be available in September. Technical papers are solicited, and anyone wishing to read one should write immediately to Mr. E. R. Thomas, Consolidated Edison

Company, 4 Irving Place, New York, from whom further particulars of the Conference may be obtained.

BRITISH NUCLEAR ENERGY CONFERENCE

A MEETING IN SEPTEMBER

The first autumn meeting of the British Nuclear Energy Conference is being sponsored by the Iron and Steel Institute, 4 Grosvenor Gardens, London, S.W.1, and will be held at that Institute on the 24th September 1957 at 2.45 p.m. A paper entitled 'High-boron Alloy Steels' by T. H. Middleham, J. R. Rait and E. W. Colbeck will be presented and discussed. The paper itself is being published in the September 1957 issue of the *Journal of the Iron and Steel Institute*.

The full programme of the forthcoming meetings of the B.N.E.C. will be published in our next issue.

MORE THAN A MUSEUM (*continued from p. 451*)

involved. When does an exhibit that represents good automobile engineering in 1930 cease to be instructional with the passage of time? Can one be sure that the reproduction of the Trafalgar Square substation of 1890 has no educational value for the layman to-day? But to our mind it is a valid division to keep in mind in assessing the worth of scientific exhibitions.

The up-to-date educational exhibits at the Museum can surely help appreciably in making Britain more science conscious. For the future needs of both recruitment and efficient administration it is vital that Britain should become so if her economy is to be maintained. Although the Science Museum is the most popular of London's museums, with 1 212 000 visitors in 1956, more publicity would attract far larger numbers. For the intelligent man it undoubtedly represents the best free entertainment-plus-instruction in London, but too often he visits it only when a nephew is spending a few days with him. The Ministry of Education should encourage him to go more often, by posters and notices in the Press. With several new post-war galleries now open, a drive to attract more visitors would be timely and fruitful. How many of the farmers that throng to the agricultural shows in the Home Counties have spent an hour in the admirable gallery displaying agricultural engineering?

Since the Faraday Lecture was founded in 1924, The Institution has been alive to the need to help the public to understand more about the achievements of electrical engineering, now probably the most important single technology in the world. That more should be done was emphasized by Sir Ifor Evans in this year's Graham Clark Lecture; few would disagree with this. Members can, and probably do, help individually with this work in discussions with friends and relations whose knowledge of electricity is on a par with that which the principal speaker at the Institution Dinner usually hurriedly confesses to. But whether they regard themselves as missionaries or not—and some people delight in disparaging their own furrow when they are not ploughing it—all members ought, as opportunity allows, to make their way to Exhibition Road, if they have not done so recently. Why? Because the new Electrical Power Collection is an admirable symbol of the industry, past and present, and electrical engineers should be familiar with it—for their own benefit, and as a gentle reminder of their educational responsibility to the community.

Contents of the Current Issues of the *Proceedings*

The date in italics is that of the Journal review or special article. Where given, the date in small capitals refers to the month in which a paper was published individually.

PART A. POWER ENGINEERING (AUGUST 1957)

R. V. MOORE, G.C., B.SC.(ENG.). PAPER NO. 2363
Development of Gas-Cooled Reactors for Power Production *June 1957*

E. T. NORRIS. PAPER NO. 2317 S, FEBRUARY 1957
Mechanical Strength of Power Transformers in Service *April 1957*

L. B. HOBGEN, O.B.E., K. A. SPENCER, B.SC.TECH., AND P. W. HESELGRAVE, B.SC. PAPER NO. 2336, FEBRUARY 1957
Cathodic Protection *August 1957*

Written discussion on **Processes contributing to the Breakdown of Electronegative Gases in Uniform and Non-uniform Electric Fields**

Discussion on **Power System Protection, with particular reference to the Application of Junction Transistors to Distance Relays** and **A Dual-Comparator MHO-Type Distance Relay utilizing Transistors** before the Supply and Measurement and Control Sections and the Mersey and North Wales Centre

Discussion on **Mine Locomotives** before the North-Western Utilization Group and a joint meeting of the North Midland Centre and Sheffield Sub-Centre

Discussion on **Germanium and Silicon Power Rectifiers** before the South Midland Supply and Utilization Group, the Mersey and North Wales Centre, the Western Centre, the Sheffield Sub-Centre and the Southern Centre

Discussion on **Breakdown under Impulse Voltages of Solid and Liquid Dielectrics in Combination** before the North-Western Supply Group

Discussion on **Underground Lighting in Coal Mines** before the North-Eastern Centre

Discussion on **Temperature Rise in Electrical Machines** before the South-East Scotland Sub-Centre, the South Midland Supply and Utilization Group and the South-West Scotland Sub-Centre

Discussion on **Highland Water Power—The Developments of the North of Scotland Hydro-Electric Board** before the Northern Ireland Centre, the Western Supply Group, the Southern Centre, the South-Western Sub-Centre and the Mersey and North Wales Centre

Discussion on **Conduction and Induction Pumps for Liquid Metals** before the North-Eastern Centre

Discussion on **Power-System Engineering Problems with reference to the Use of Digital Computers** before the North Staffordshire Sub-Centre

PART B. RADIO AND ELECTRONIC ENGINEERING (JULY 1957)

See the issue for July 1957, p. 434.

PART C. MONOGRAPHS (MARCH 1957)

See the issue for March 1957, p. 187.

LONDON REPORT

MEASUREMENT AND CONTROL SECTION

Bats, Bees and Brains

When Mr. F. W. Meredith gave the Annual Lecture of the Measurement and Control Section on the 7th May, he took his audience on a fascinating excursion into the world of living things. A written version of the lecture will be published in a future issue.

The title of the lecture was *Invention and Nature*. Mr. Meredith said it was fortunate that the Patent Office took no account of anticipation of an invention by living organisms. Many of man's latest achievements had existed, in principle if not in detail, as part of the equipment of living things for millions of years. But we have still not quite achieved such commonplaces of nature as the making of fur.

Animal life could scarcely have existed had not the process of evolution discovered the automatic regulation of temperature, which made warm-blooded life practicable. The animal body has innumerable elaborate controls of its chemical and physical condition. We have 'volume control' of the aperture of the eye, and automatic regulation of the pressure and composition of body fluids. A more specific anticipation is the bat's 'radar' equipment. A bat can fly among stretched strings in complete darkness without touching them. It does this by sending out supersonic squeaks, and catching the echoes with its specially developed ears.

Man, Mr. Meredith said, can learn from the achievements of nature, since, when a function has been shown to be physically realizable in living media, this is a challenge to the engineer to achieve it in his medium of mechanical and electrical elements.

The application of the electric current from a battery exists in the 200 species of electric fish. They use the current not only for defence but also for detecting obstacles.

A particularly vivid example of a solution of a problem that man has not yet completely solved is provided by the *halteres* of flies—the rod-like vibrators behind the wings, the function of which is that of an alternating gyroscopic stabilizer. Mr. Meredith gave a detailed account of the efforts of various inventors, including himself, to make use of this same principle (that of the Foucault pendulum) to stabilize aircraft. Man has here been less successful than nature.

As an elaborate system of communication, using coding, Mr. Meredith cited the communication system of the honey-bee, which is a sort of ritual dance. The bee takes bearings from the sun, and uses the ability to detect the direction of polarization of light when the sun is obscured. An identical principle has been recently used by man for polar navigation, when normal compasses become unreliable.

The human brain, the lecturer said, with its 10000 million cells, is of an order of complexity beyond human imitation. But its study has inspired fascinating models, and some of its functions can be imitated.

By these and many more examples, Mr. Meredith convinced his audience that there is little new under the sun, and that the would-be inventor could profitably start with a quick course in biology as a source of inspiration.

The chair was taken by Dr. Denis Taylor, and the lecture was obviously very warmly appreciated. A. T.

SUPPLY SECTION

Gargantuan Transmission Schemes

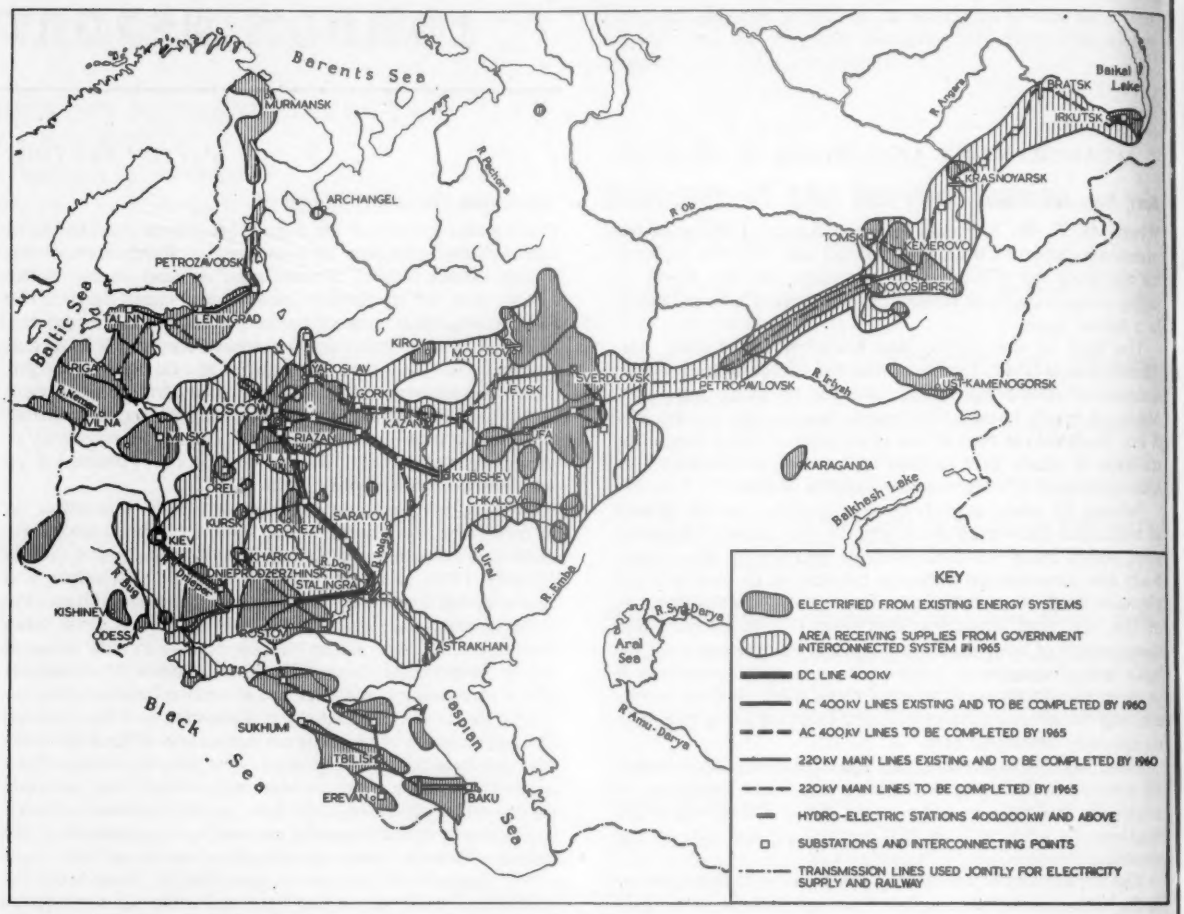
The Annual Lecture of the Supply Section on the 24th April was delivered this year by two eminent Russian engineers, whose subject, *400 kV Transmission Systems in the Soviet Union*, was of profound interest and importance. The audience was distinguished by the presence of His Excellency Mr. J. A. Malik, the Russian Ambassador, and Sir Gordon Radley. The Chairman, Professor M. G. Say, who was deputizing for Mr. P. J. Ryle, introduced Mr. S. S. Rokotyan and Mr. B. P. Lebedev. In Russian, Mr. Rokotyan indicated the pleasure given to the Soviet engineers at the possibility of presenting the lecture, which Mr. Lebedev proceeded to deliver in commendable English.

In a compressed lecture it is obviously impossible to do justice to the character and extent of the transmission systems which are in service or planned in the Soviet Union. Already 1050 miles of 400 kV lines link Kuibishev and Moscow, 1400 miles of extensions, at the same voltage, are under construction, and by 1965 an additional 4300 miles should be installed. These systems do not include those of similar proportions planned for Asiatic Russia. The problems of d.c. transmission at 400 kV are also being boldly tackled on a 300-mile length of line linking Stalingrad and the Donbas. The appreciation of planning on this scale is difficult for those who are used to the compactness of a densely industrialized country, and even more so when it is realized that not only do the lines span regions with widely different climatic conditions but the distances covered are so great that the variation in local time is significant in load spreading.

Mr. Lebedev then dealt in considerable detail with the technical considerations leading to the choice of a triangular spacing arrangement of bundle conductors, with system stability problems and their relationship to equipment design, and with the provision of compensating devices. The systems are solidly earthed and provided with lightning protection by earth wires. The line insulation level approaches 2000 kV (peak), and diverter-protected substations are co-ordinated to a peak level of 1500 kV. The significance of these levels emerged later, when the commissioning tests of the initial sections were mentioned.

In design of the lines and towers, since some single circuits are employed, reliability has been a prime consideration, and investigations were made into conductor construction, tower design and special forms of line-clamping devices. Weather and soil conditions added their problems to the studies, and it would appear that the Russian engineers, in meeting the diverse requirements, exercised considerable ingenuity in the constructional techniques used.

The word 'gigantic' does not overstate the character of the fantastically large substations which the 400 kV schemes involve. The sizes are such that single-phase units of equipment are used, and even then transformers are assembled on site into tanks fabricated in adjacent workshops. Three-phase transformer groups having ratings of 500 MVA are contemplated, and air-blast switchgear rated at 15000 MVA is being designed. Two 3-phase bays, each with its main units and ancillary gear, would cover a football pitch.



The supply areas and high-voltage transmission system of the U.S.S.R.

Examining the commissioning and the experiences recently obtained, the Russian engineers have gained much valuable data on the Kuibishev–Moscow line. Although the line was incomplete, it was possible to provide a temporary feed at the Moscow end in the winter of 1955–56, and a series of measurements was made. Spring 1956 saw the first complete circuit in use, and later that year the second circuit was commissioned, enabling over 800 MW to be transmitted from Kuibishev.

The initial testing programme included determination of line parameters and frequency response over a range of 10 to 130 c/s. Corona losses of the lines were measured under different conditions, and observations made on the weathering of the lines. Tests were also made with a varying number of shunt reactors and different line lengths, and startling over-voltage conditions occurred, one instance being a voltage of 800 kV at the open end of the complete line.

Under light feed conditions, solid and arcing faults and transient switching over-voltages received study, and the behaviour of the air-blast switchgear has been reported as satisfactory. Other tests revealed the possibility of single-phase automatic reclosing on lines 300 miles long.

Experience during the past year has indicated that the performance of the lines under a variety of weather conditions has vindicated the initial designs. The Russian engineers are now considering the practicability of operating the 400 kV lines at 500 kV in view of the possibility of limiting internal over-voltages and the behaviour of the equipment under the over-voltage conditions described. The significance of the insulation levels now becomes important, since if the line voltage can be raised to 500 kV it is estimated that the transmitting capacity can be increased by 40%—an extremely worth-while economic advantage. The considerations are giving place to reality, since in March this year experiments were made in the field on a short length of line with a connected substation, and the results are being studied against a repeat test this summer.

Plans for using even higher system voltages of 600–750 kV are being developed both for lines and equipment, and the outcome will be universally awaited with interest.

Professor Say summarized the impressions the lecture had obviously created on the audience, and called on Sir Josiah Eccles to indicate members' appreciation. Sir Josiah complimented the authors on the contents of their contribution and the manner of the delivery. Drawing on his own experience in the Soviet Union during a recent visit, he emphasized the nature of the projects, expressed the hope that interchanges will make for mutual understanding and conveyed in gracious

terms the thanks of those present. Mr. J. E. L. Robinson, supporting Sir Josiah, endorsed the opinion that the lecture rightfully took its place in, and added lustre to, the excellent series of Annual Lectures given to the Supply Section. Full acclamation was then given to the authors.

Amidst applause, the President welcomed the Soviet Ambassador, and after giving his impressions of the noteworthy developments recorded, he went on to suggest that members would welcome remarks from Mr. Malik.

His Excellency expressed his pleasure at having the opportunity of addressing members; he then outlined the nature of the activities of the authors and said that the two Russian experts had jointly transmitted learning from Moscow to London—an even greater distance than that of their schemes. He went on to stress the importance of contacts over a wide field of activities, which he was convinced could only be to the mutual benefit of the respective countries. He considered that the presentation of lectures and the exchange of delegations were helpful ways towards that end.

The Chairman thanked His Excellency and agreed that in engineering and in other studies common ground for unification of ideas existed. F. C. W.

Voltage Stabilization

A paper on the *Voltage Performance of Series Capacitors in Transmission and Distribution Lines*, by Mr. J. M. Magowan, was presented on his behalf by Mr. L. L. Langton at a meeting of the Supply Section on the 22nd May. The paper is reviewed on p. 464. In his introduction, Mr. Langton talked about aspects of supplying a scattered load area in Southern Rhodesia. The majority of the loads are sawmills and small mines, which, when working, do so on a three-shift basis. The individual loads are usually small, and the distances are often considerable, for example 25 miles at 11 kV. Moreover the load power factor is normally bad, and the sawmills impose sudden changes. It was the necessity of improving the performance of such lines that resulted in an investigation and in the subsequent installation of three series-capacitor systems, two at 11 kV and one at 88 kV.

The discussion was opened by Mr. W. Casson, who pointed out that the paper was the first presented to The Institution in which experience with series-capacitor installations was covered. The Central Electricity Authority had been studying the whole question, and some tests had been made on an installation at Melksham. Their conclusions were that series capacitors were useful where the overall R/X ratio of the circuit was high and the load power factor was low, conditions similar to those met in Southern Rhodesia. There were a number of other useful applications, but at present the major difficulty was the inadequacy of the available devices for limiting the voltage on the capacitor bank.

A number of other speakers stressed the necessity for research into the development of a suitable shunt protective device. Ideally the capacitor bank should be reinserted into the circuit as soon as the over-voltage condition has ceased, and the protective device, when carrying the excess current, should not generate sawtooth waves. Equally, the cost should not be high. In some small installations the risk has been accepted, and no protective devices are used.

A plea was also made for the use of small capacitor units connected in series-parallel as required. This would enable a given bank to be varied and moved from one location to meet the requirements at another.

The mathematics was a bait to many. There were suggestions for simplification and easier presentation; in particular the figure of merit β was the subject of much query because it lent itself to many definitions.

The Chairman, in proposing a vote of thanks, congratulated Mr. Langton for having so ably deputized for Mr. Magowan. J. R. M.

UTILIZATION SECTION

Optimistic Forecast

At the meeting on the 9th May a lecture was given to the Utilization Section by Mr. H. J. Miller on *The World's Copper Resources*.

Contrary to the depressing views which are expressed from time to time and which often receive much publicity, Mr. Miller was optimistic regarding the future of the world's copper resources. Speaking of the relationship between the growth of the electrical industry and that of copper production, he said that the one could not advance without the other. It appeared that the amount of copper consumed by the electrical industry was very nearly half of the total supply.

It was important to realize, he said, that the figures published by mining companies regarding their ore reserves were for proved amounts only, and these often with never more than ten years in mind at any one time, although many of the mines had operated for over forty years. A source of supply which supplements the production of newly-mined copper is the large and increasing quantity of recovered scrap metal.

Mr. Miller was of the opinion that in the near future there would be a vigorous growth of both the production and consumption of copper, and he emphasized that the primary metal producers were required to produce only the difference between the total demands and the supplies from secondary sources. There were abundant reserves of ore for the next fifty years, and even then the prospect was that the proved reserves would still be ample. The lecture concluded with an interesting film covering all stages of production from the mining of the ore to the finished metal.

A vote of thanks was proposed by Mr. D. B. Hogg and seconded by Mr. R. A. Marryat.

Hey Ding a Ding, Ding

The Annual Summer Visit for members of the Utilization Section and their ladies was held at Stratford on Avon from the 31st May to 2nd June under the chairmanship of Mr. H. J. Gibson. A total of 128 persons participated.

About half of the party were accommodated at the Alveston Manor Hotel (the headquarters during the visit), a charming old-world residence situated in delightful surroundings, just to the south of Clopton Bridge over the Avon.

All the journeys were made in coaches, and this contributed largely to the very friendly atmosphere which prevailed and which was such a marked feature throughout the visit.

The programme of arrangements started on the Friday evening with a Dinner-Dance at the Welcombe Hotel, as the guests of the Midlands Electricity Board, whose Chairman, Mr. W. S. Lewis, welcomed the party and said that he hoped their week-end would be both pleasant and instructive. The party were particularly appreciative of the very appropriate souvenirs which the Board so thoughtfully presented to each member and lady.

Although it was well past midnight before everyone returned to their hotels, it was necessary to be up betimes on

the following day, since nine o'clock on Saturday found the party on their way by coach to the works of Garringtons Ltd., of Bromsgrove, on a gloriously sunny morning. The route taken passed many places of picturesque and historical interest. More technical features of the landscape were the h.v. distribution system of the Midlands Electricity Board and the newly erected towers for a section of the 275 kV Supergrid transmission line of the Central Electricity Authority.

On arrival at Garringtons Ltd., coffee was served, after which a comprehensive tour of the works was made, including the electrical distribution system, and the Area Board substation supplying the present maximum demand of approximately 20 MVA. The traditional forge shops, involving drop-stamping equipment and oil-burning furnaces, formed a striking contrast to the modern press forges, which were equipped with extensive induction-heating installations. Although the works are not normally in production on Saturdays, Garringtons Ltd. had very kindly gone to considerable trouble and expense to arrange for many items of this modern equipment to be shown in actual operation.

Since many members were by now a little footsore, and the heat of the sun was increasingly making itself felt, all were glad to relax in the comfort of the coaches, which then proceeded via Wychbold (passing the B.B.C. masts used for the transmission of the Midland Home Service and Light Programmes) to the Chateau Impney Hotel, where lunch was provided by the hospitality of the English Electric Co.

The drive back after lunch was through Droitwich and Alcester, and on arrival at Stratford a number of members spent the rest of the afternoon lazing in the heat. In fact the immediate Past-Chairman of the Section really made an efficient job of this, being observed lying full length complete with pillow in the shade of a large tree.

In the evening the party attended a well-acted and enjoyable performance of *As You Like It* at the Shakespeare Memorial Theatre, after which they were shown the lighting equipment installed there.

On Sunday morning, again in brilliant sunshine, a drive was taken to Charlecote Manor. Although the estate has been occupied by the Lucy family for nearly 900 years, its care in 1946 passed to the National Trust.

The party were conducted over the hall by well-informed guides, one of whom possessed a delightful touch of humour, which was greatly appreciated by all his listeners. It is worth recording that, when viewing the contents of the drawing room, the Chairman-elect of the Section was observed carefully perusing a somewhat ancient score of music entitled *Welsh Melodies for the Harp* and taking an unusual interest in the instrument itself, which stood nearby. Whether this portends activity in this direction on his part after future Committee dinners is a matter of conjecture by members of the Committee.

The tour of Charlecote concluded with a visit to the brewhouse. Members were told that the home-brewing apparatus was so well preserved that it could be used nowadays—a somewhat tantalizing piece of information for many in view of the temperature on the day of the visit.

However, an opportunity soon presented itself for slaking thirsts, when, after driving through Warwick, the party reached Chesford Grange Hotel, Kenilworth. Here the visit ended with an excellent lunch, at the conclusion of which the Chairman, supported by Mr. J. F. Shipley, Past-Chairman, thanked all those who had extended hospitality or had contributed in any way to the undoubted success of this two-day Summer Visit.

R. H. R.

NEWS *from Abroad*

ADELAIDE

SOUTH AUSTRALIA OVERSEA COMMITTEE

Accelerated Particles—Accelerated Design

Members in South Australia were fortunate in hearing lectures from two oversea visitors at the first two meetings of the 1956–57 Session.

Mr. C. W. Miller has been visiting Australia and New Zealand in connection with the installation of 4MeV linear accelerators in several Antipodean hospitals. At our March meeting, held jointly with the Adelaide Branch of The Institute of Physics, he gave a lecture on the development of electron and proton linear accelerators. He compared the accelerating process to surf riding, and amused his audience by screening a rather murky lantern slide of an Australian beach scene to illustrate his point. He said he felt diffident about exhibiting it to Australians and asked his audience to lay blame for its shortcomings at the door of the publicity department at Australia House, whence it came! Other slides showed how high-energy particles are applied to such diverse purposes as the radiography of steel castings, sterilization of foodstuffs and pharmaceutical products, and the irradiation of polymers to induce cross-linking of their molecular structure.

In April we joined forces with the Adelaide Division of The Institution of Engineers, Australia, to hear Mr. D. McDonald present a paper entitled *Power Transformers for High-Voltage Transmission, with special reference to Design Trends.* Mr. McDonald surveyed the variables which have to be determined by the transformer designer, and showed how he sets about his task. The long-hand methods commonly used are so time-consuming that he is usually not able to achieve an optimum design for a given specification. If, however, a number of designers all pool their best effort, knowledge and experience in the preparation of a programme for a high-speed digital computer, time is no longer restricting and the probability of achieving the optimum becomes a certainty. In addition, the computer gives results which converge so rapidly to the correct solution that the starting data are of little consequence. Mr. McDonald concluded his lecture by describing, with the help of slides, how this programme had been developed and some of the results achieved with it.

We in South Australia would like to express our gratitude to our visitors for finding time in busy programmes to tell us something of the interesting fields in which they work. As a member of Council of The Institution, Mr. McDonald returns home bearing our greetings and with an insight into our local conditions.

Computer Meetings

During the first week of June 1957 a Convention on Computers was held at the Weapons Research Establishment, Salisbury, South Australia, at which papers were presented embracing most aspects of the theory and practice of high-speed computation applied to scientific research, data processing and commerce. A number of visitors from universities,

research establishments and industry in England and the United States accepted invitations to contribute to the proceedings of the convention.

The South Australia Committee arranged three meetings in Adelaide at which visitors from England generously found time in their already heavily filled programmes to give talks; these were designed to inform the non-specialist engineer of recent developments in some subjects discussed at the Convention.

On the 31st May Dr. M. V. Wilkes gave an illustrated lecture entitled *Digital Computers and their Importance to the Engineer*. After a brief historical introduction in which he mentioned the pioneering work of Babbage in the nineteenth century, Dr. Wilkes described how a modern computing machine works and how its form is dependent on the use for which it is designed. Data-processing machines, for example, have very highly developed input and output organs. He showed slides of some of the machines built in the last ten years and mentioned some of the projects in which they have been employed, notably the determination of the structure of the molecule of the vitamin B_{12}. Probably the most successful application of the machines to engineering had been in transformer design, where the problem could be stated by precise mathematical equations. In many fields of engineering, however, there is a real need to improve the mathematical models on which designs are based. Many of these are typified still by the famous problem about the elephant whose mass may be neglected.

A week later, Dr. T. Kilburn, in a lecture entitled *Some Engineering Aspects of Digital Computers*, discussed the various ways in which digital information may be stored, pointing out that storage is the central problem in computer design. He described and showed slides of stores making use of perforated paper tape, magnetic tape, magnetic drums and discs, cathode-ray tubes, delay lines and matrices of minute ferrite toroids. He compared their cost, capacity and time of access.

Our third speaker was Mr. O. S. Puckle, who read a paper entitled *Numerically Controlled Machine Tools and the Production Engineer*, which described the principles of one form of analogue control using tapped toroidal transformers. In this system a programme, which lists x and y co-ordinates of points on the path of the centre of the milling cutter starting from an origin off the edge of the work, is prepared from a drawing of the work-piece and transferred to a punched paper tape. The sizes of the intervals between the positions of successive points specified in the programme depend on the dimensional tolerances and finish required. To reduce to an acceptable level the work of preparing the programme, a parabolic interpolator is used to compute intermediate co-ordinates on curves after the specified co-ordinates have been converted into analogue voltages. Further linear interpolation is used between points provided by the parabolic interpolator.

The resultant analogue voltages are compared with voltages representing the positions of the slides of the machine tool, and the error signals derived from the comparison are amplified and fed to the motors driving the lead-screws. Errors caused by distortions in the frame of the machine or by deflection of the cutting spindle caused by heavy loading are outside the feedback loop, and these can result in errors in finished dimensions if suitable precautions are not taken. A great deal of work is going into the design of machine tools of greater rigidity which will be able to make full use of the higher cutting speeds made possible by numerical control.

Mr. Puckle stated that the use of numerically controlled machine tools speeds up production of small quantities of component parts by a factor of five to fifty times and is well suited to tool and jig making.

All these meetings were very well attended and were followed by animated discussions. We are most grateful to the visiting lecturers for adding so much to the value and interest of our current session. J. W. C.

BRISBANE

QUEENSLAND SECRETARIAT

The 1956 Christmas Luncheon was held at the Carlton Hotel, Brisbane, on the 13th December. There was an excellent attendance of thirty-seven members, and, as is customary, one guest from another profession was invited to attend and to deliver a short talk on a subject of public interest. On this occasion the guest was Mr. J. A. Holt, Co-ordinator General for Public Works in the State of Queensland.

In introducing Mr. Holt, the Chairman, Mr. A. S. Faulkner, took the opportunity of extending Christmas greetings to those present, and in response to the toast in his honour Mr. Holt delivered an interesting address on *Financing of Public Works*. He outlined various ways in which capital is raised and drew attention to the difficulty, in these times of scarcity of public funds, of fixing priorities for the allocation of available resources.

A vote of thanks was proposed to the guest speaker by Mr. J. E. Morwood. W. I. G.

UGANDA

The Uganda Electricity Board have announced that contracts have now been placed for the supply and erection of 600 miles of distribution lines to be erected between Mityana and places near the Kenya border, in the foothills of Mount Elgon.

The total value of the contracts, together with the cost of transformers and switchgear (ordered separately), way-leaves compensation, engineering fees and interest during construction, is just over £1 000 000, of which over 95% will be spent in Uganda or in the United Kingdom.

Most of the work, which includes 33 kV, 11 kV and low-voltage lines, is expected to be completed by the end of 1958. When completed, an area of about 8000 square miles will have a comprehensive electricity supply network providing and making available electricity supplies in the rural areas on an ever-expanding scale.

Construction will also start on the Kikagati to Mbarara extension later this year and will be carried out by the Board's own staff.

OVERSEA ATTENDANCE REGISTER

During the period 1st June to 30th June the following members called at the Institution building and signed the Attendance Register of Oversea Members:

ADLEY, A. G., M.A. (Johannesburg)
ANYADIKE, F. O. O. E. (Lagos)
APPLEBY, J. H. (Caracas, Venezuela)
BELLE, A. D., B.SC.(ENG.) (Nicosia)
CLARK, R. G. (The Hague, Holland)
DRAKE, F. A. (Calcutta)
FAWCETT, J. W. (Calcutta)
ILES, A. R. (Lebanon)
KARSTEN, P. M. (Boston, U.S.A.)
MEADE, J. (Lagos)
PICKEN, G. H., B.SC.TECH. (Kuala Lumpur)
RAMSBOTHAM, Major W. A. M., R.E.M.E. (Singapore)
SCOTT, E. (Kuwait)
SHAWEESH, H. M. (Amman)
STANDEN, M. H. L., M.A. (Nairobi)
TRENT, H. E. (Pennsylvania)
WOOD, H. B., B.SC., M.E. (Sydney)
WOOD, I. J. (Salisbury, S. Rhodesia)

NEWS *from the Centres*

BRISTOL AND CARDIFF

WESTERN CENTRE

Annual Dinner-Dance

The Annual Dinner-Dance is usually the highlight of the session, and this year it was no exception. It has now become so much an established function that there are always high expectations, and few, if any, are disappointed.

Professor G. H. Rawcliffe, Chairman of the Western Centre, accompanied by Mrs. Rawcliffe, presided over the gathering. The toast of 'The Institution' was proposed by Sir Phillip Morris, Vice-Chancellor of the University of Bristol. In an informative and witty speech, he naturally stressed the purpose and value of education and paid tribute to the Chairman for the work he had done in the University. In a pleasant speech in response to this toast, the President, Sir Gordon Radley, spoke of the relationship between The Institution and the universities. It was natural that the theme that evening should be technical education, and it was obvious that this was receiving primary consideration in many places.

Mr. J. F. Wright, Vice-Chairman of the Western Centre, proposed the toast 'The Guests and Kindred Societies', and ably referred to the very distinguished guests present. Professor J. A. Coutts, Dean of the Faculty of Law at Bristol, very wittily responded, and by the blending of education, university, law and The Institution, provoked admiration for what words can do.

The toast of the Chairman was proposed by Mr. T. G. Dash, a Past-Chairman of the Western Centre, who paid a well-deserved compliment to the Chairman for his able leadership of the Centre during his year of office. Professor Rawcliffe in turn paid tribute to the help he had received from the university, the Western Centre Committee and not least from the Hon. Secretary, Mr. F. F. Freeling.

The arrangements were in the hands of a local committee headed by the Assistant Local Hon. Secretary, Mr. W. D. Morgan, who should be congratulated on the excellent arrangements made. The dance went on into the early hours of the morning, and a good sum was collected for the Benevolent Fund as a result of a raffle organized by the local Committee.

Joint Meeting on Russia

A somewhat unusual joint meeting of The Institutions of Civil, of Mechanical and of Electrical Engineers was held at the South Wales Institute of Engineers, Cardiff, on the 21st May, when Mr. W. K. Brasher and Mr. E. G. Sterland, A.M.I.Mech.E., addressed the meeting on *Engineering Education in the Soviet Union*. There was a very good attendance of members, together with support from the educational institutions of the district. It is evident that those interested in technical education are most anxious to discover what is being done in the U.S.S.R.

Mr. Sterland gave a comprehensive survey, touching lightly on various incidents of the tour and salient objects of interest. Mr. Brasher followed with a more specific approach and made comparisons with what we do here. The discussion that followed was really vigorous, and there was almost a queue to speak in it. It was evident that each speaker had a point of view and wanted information to dispel or confirm his view. The speakers dealt very adequately with the numerous questions, and they also made some pointed remarks on what should be done for the benefit of technical education and for the improvement in numbers and quality of students so very urgently required.

Many felt that this successful meeting indicated that more joint meetings should be held in the future; the meeting should make it easier to arrange others.

Mr. J. Vaughan Harries proposed a vote of thanks to the speakers, which was carried with acclamation. D. J. T.

ISLE OF WIGHT

SOUTHERN CENTRE

Oversea Meeting

The Southern Centre, under the Chairmanship of Mr. H. Robson, visited the Isle of Wight to hold their second Summer Meeting on the 9th May, when a party of over forty members and guests had the pleasure of listening to a paper on *Colour Television* by Mr. C. J. Stubbington.

Some members of the Southern Centre at the Isle of Wight meeting

Mr. C. J. Stubbington is on the extreme left. Mr. H. Robson, Chairman of the Centre, is seated on the right of the photograph.

The author dealt most comprehensively with the principles and problems of colour transmission, explaining clearly the several systems now in use, and the possible future trends.

A most interesting discussion followed, during which the author ably dealt with the questions raised. E. A. L.

NORTH MIDLAND CENTRE

Annual General Meeting

The 1956–57 Session was brought to a formal close at the Annual General Meeting on the 7th May 1957, under the chairmanship of Mr. W. K. Fleming. Mr. J. F. Cunningham thanked the retiring scrutineers, and Mr. A. R. Rumfitt and Mr. W. Bowman were elected as scrutineers for the forthcoming session. The Treasurer, Mr. J. V. Werrell, presented the Accounts with a very lucid explanation, and these were approved. Mr. F. Barrell, the immediate Past-Chairman, thanked the retiring Honorary Auditors, Mr. J. J. Swarsbrick and Mr. J. D. Green. It was noted that Mr. Swarsbrick was leaving the Centre to live in retirement in the south, and our best wishes for a long and happy retirement were expressed. Mr. H. S. Moody proposed Mr. J. D. Green and Mr. A. J. Evans as the new Honorary Auditors, and they were duly elected. The Chairman reviewed briefly the work of the session, saying that the average attendance at the eight ordinary meetings had been 82, with a maximum of 121. He complimented the Utilization Group Chairman, Mr. R. Spence, on the fact that their average attendance of 53 was a 20% increase on last year. Two Student Prizes, for distinction in the Higher National Certificate examinations, were awarded to Mr. S. A. Lord and to Mr. D. Dukes, who was absent on National Service. Mr. J. G. Craven made the appeal for the Benevolent and Homes Funds, and a hat collection produced a contribution of £12 6s. 9d.

The Chairman then introduced Professor H. C. Versey, who gave a short lecture entitled *A Trip to Mexico*. He explained that some months ago he made a visit to Mexico as a member of a geological party. The descriptions, aided by excellent colour transparencies, gave us a vivid picture of the volcanoes Popocatepetl and Ixtaccihuatl, which dominate the countryside surrounding Mexico City. Scenes in Mexico City itself showed the extent of their subsidence troubles arising from the too-thorough pumping of water from underground sources. The party had also made a visit to University City to see the wonderful new buildings, whose architecture provided examples of a marriage between advanced functional design and Aztec murals. We were also shown views of the millionaire's paradise, Acapulco, on the Pacific coast. Underlying the lecture was a most interesting description of the geological formation of the country. A vote of thanks to Professor Versey was proposed by Mr. A. J. Coveney.

Golf at Sandmoor

The Annual Golf Competition of the North Midland Centre, in aid of the Benevolent and Homes Funds, was held at Sandmoor on the 28th May, in perfect weather. This year there was better support than has obtained in the past few years, and seventy members and guests played in the Competition. The main prize, the Woodhouse Trophy, was won this year by Mr. A. J. Evans, and this was presented at the very pleasant dinner which followed. The Chairman, Mr. W. K. Fleming, thanked Mr. J. D. Nicholson for his work in organizing the Golf Competition and congratulated him on the success of his enterprise. Mr. H. S. Moody appealed to all members to support the auction which followed, and a brilliant performance by Mr. W. Plumb as auctioneer raised a sum for the Benevolent and Homes Funds which should equal that of previous years.

The fourth District Meeting was held on the 28th February 1957, when Mr. R. G. Hibberd presented for discussion the paper entitled *Germanium and Silicon Power Rectifiers*, of which he is co-author with Messrs. T. H. Kinman, G. A. Carrick and A. J. Blundell. The paper dealt with the essential theory of operation of semi-conductors, the production of alloy junctions for power rectification purposes and their electrical properties. Some very startling figures were given for the physical size of these rectifiers and for the currents carried by them under steady and fault conditions, and members were much impressed by the conversion efficiencies in comparison with metal and mercury-arc rectifiers.

The phenomenon of hole storage and the suppression of radio interference were dealt with, and our understanding of the subject was greatly assisted by the excellent slides and exhibits which the speaker had provided. A discussion, which was opened from the chair by the Convener, Mr. W. S. Milner, was very lively, the ten contributors putting many interesting questions, which were adequately answered by the speaker. The vote of thanks was expressed by Mr. T. H. Bradley.

The fifth District Meeting was held on the 11th April 1957, when Mr. L. H. Dickerson presented the late Mr. T. Lawrie's paper entitled *Highland Water Power—the Development of the North of Scotland Hydro-Electric Board*. The paper outlines the various schemes of utilization of the natural water resources in the different catchment areas, and the introduction was profusely illustrated by colour slides of power stations, dams and buildings. Slides were shown of the civil engineering works, which include buttress and prestressed dams. The preservation of the amenities and the use of local natural stone was specially mentioned, and the maintenance of the Scottish salmon preserves by the provision of fish ladders and fish passes was dealt with. Six members, led by the Convener, Mr. W. S. Milner, joined the discussion, and the meeting was in complete accord when Mr. C. Cameron-Kirby ably thanked the speaker.

GRADUATE AND STUDENT SECTION

On the 9th April the Students' Lecture, *Digital Computers and how they may help the Engineer*, was presented by the author, Mr. M. V. Wilkes. Members found this a most interesting paper on a subject which is certain to play a tremendous part in engineering in the future. It was, therefore, with great interest that members listened to Mr. Wilkes's discourse, in which he described not only the uses of computers but also something of their construction.

Lakes and Reactors

On the 3rd May twenty-five members left Leeds by coach for a most eagerly anticipated visit to the nuclear power station at Calder Hall. The whole day was packed with interest, because not only did we find the visit a feast of engineering but we took delight also in the tour of the Lake District which ensued. Altogether it was a most memorable day.

Annual General Meeting

The Annual General Meeting was held on the 11th May, under the chairmanship of Mr. D. Pitts, and, after the formal business had been completed, members enjoyed several short films on plastics, nylon and refrigeration. J. L.

MANCHESTER

NORTH-WESTERN CENTRE

Annual General Meeting and Presentation to Mr. T. T. Evans

The Annual General Meeting was held at the Engineers' Club in Manchester on the 7th May 1957.

In view of the fact that Mr. T. T. Evans, the Honorary Secretary had intimated his intention to resign at the end of the present session, the members of the North-Western Centre and of the North Lancashire Sub-Centre decided to recognize his exceptional services to the Centre and to The Institution generally by subscribing for a suitable gift.

Mr. Evans has been Honorary Secretary of the Centre continuously since 1942, and had previously served as a member of the Centre Committee from 1935.

The gift took the form of a television set, which was presented to Mr. Evans by Mr. F. R. Perry, Senior Vice-Chairman, in the unavoidable absence of the Chairman, Mr. T. E. Daniel. A book of signatures of all contributors was prepared, and the photograph shows Mr. Evans receiving the book from Mr. Perry.

Mr. Perry enlarged on Mr. Evans's exceptional period of service, and mentioned that, in addition to present members of the Centre, many others not now resident in the area had asked to be allowed to subscribe. Mr. Perry spoke of Mr. Evans's enthusiasm and helpfulness in all matters relating to the activities of the Centre and his unfailing courtesy and cheerfulness.

Mr. Evans, in thanking members for the gift, said that during his period of office he had seen the setting up of the North Lancashire Sub-Centre and the four specialized Groups. No other Centre has the full complement of Groups, and he felt that, in handing over to a successor, the Centre was in a very active and healthy condition, and he had every confidence in its future. No other Local Centre holds as many meetings as does the North-Western Centre, and while not the largest in total number of members, he thought it could claim to be the most active.

After the Annual General Meeting, Mr. F. Day, Honorary Secretary of the North Lancashire Sub-Centre, delivered an informal lecture on *Lighting for the Amateur Stage*, in which he gave an account of the evolution of the theatre from about 500 B.C.

The Annual Report recorded that twenty-nine meetings had been held during the session. H. D.

Mr. T. T. Evans (left) receives the book of signatures from Mr. F. R. Perry, Senior Vice-Chairman

PITLOCHRY AND GLASGOW

SCOTTISH CENTRE

Playboys in Pitlochry

In the excellent weather that has come to be expected for the Scottish Centre Spring Meeting, about sixty members and guests assembled at the Pitlochry Hydro Hotel for the week-end of the 24th–27th May. After the gathering on Friday evening, the events of Saturday followed the usual pattern—the Hutcheson-Winning Golf Trophy was played for in the morning, with Mr. P. McNee of Glasgow as the winner, and in the afternoon the party drove through the incomparable scenery around the Tummel and Loch Rannoch, with visits to the Errochty Dam and to the site of the new Gaur hydro-electric scheme, where members were welcomed and entertained to tea by Mr. A. A. Fulton, General Manager of the North of Scotland Hydro-Electric Board. In the evening many members saw *The Playboy of the Western World* at the Theatre in the Hills. For those who had been regular visitors to the theatre at previous Spring Meetings, the occasion was tinged with sadness, owing to the death, two days before our visit, of Mr. John Stewart, the founder and director of this unique playhouse.

The Spring Meeting always falls on the wedding anniversary of a very well-known member, and some celebration, with a little tomfoolery such as a rearrangement of the bedroom furnishings, is usual; this occasion was memorable in that the perpetrators of the tomfoolery operated on the wrong bedroom!

Sunday and Monday were devoted to leisured pursuits such as putting competitions, and the Centre Chairman, Professor F. M. Bruce, was diverted from his usual mountaineering exploits to a close study of the mechanics of golf; a diploma, awarded for certain social activities, was suitably endorsed to mark his inefficiency at the noble Scottish pastime.

At the beginning of each year the location of the forthcoming Spring Meeting is invariably discussed, but it seems impossible to find a more delightful place than Pitlochry, and the success of this year's meeting has already led to a tentative booking being made for 1958.

Annual General Meeting

The Annual General Meeting of the Centre was held in Glasgow on the 29th May. After the formal business, Mr. J. A. Banks gave his paper, illustrated by slides and an excellent colour film, on *The Allt-na-Lairige Pre-stressed Concrete Dam*. This paper has been selected by The Institution of Civil Engineers for presentation in Canada, and, hearing Mr. Banks's description of this outstanding and novel constructional work, we realized clearly why it had been honoured in this way. E. O. T.